THE DAIRY PRACTICES COUNCIL®

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GUIDELINE FOR
MILKING CENTER WASTEWATER

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Milking Center Wastewater

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SECTION 1: INTRODUCTION

All dairy farms produce and then must dispose of wastewater from their milking centers. There is great variability from farm to farm in the amount of wastewater produced as well as the concentration of contaminants. There are also a number of ways to treat the effluent. Each dairy farmer needs to evaluate the specific situation on his or her farm to determine the best treatment method for that farm.

Many different contaminants can be introduced into the milking center wastewater, but the most significant ones are milk and manure. Milk has a very large oxygen demand on the waste treatment system. Contamination of milking center wastewater with milk will create an anaerobic environment unless positive steps are taken to prevent this from occurring. An anaerobic environment is less efficient than an aerobic one; breakdown of the organic matter is slower, and odors are produced as the wastewater degrades anaerobically. Manure is usually not a major contaminant in the wastewater from milking centers without a milking parlor. Manure solids will fill up settling tanks with floating incompletely digested fibers while also settling out denser materials in the bottom of the tank. If these solids are allowed into a soil treatment system, they will rapidly plug the system.

The milk, manure, and some detergents contain nutrients that can cause excessive growth in down-stream water bodies. Phosphorus (P) is often of particular concern, since it is usually the limiting nutrient in fresh water. Springman et al shows that the average of nine milk houses produced 1.65 pounds of P per cow per year. A Cornell report giving mass balances of nutrient flows in and out of farms shows that farms import around 50 pounds of P per cow per year more than they export. Most of the excess P is in the manure, and when spread on the land most of the P is fixed to soil particles and doesn't leave the farm. Although the amount in the milk house wastewater is much less than the unaccounted P in the farm system, the P in milk house wastewater comes from a point source, is often visible, is more likely to be in a soluble form, and is often discharged so that it can soon enter a watercourse. The perception of a pipe discharge and the accompanying plume of discolored or foamy water is not an appropriate one for promoting goodwill toward agriculture.

In the past when the manure from dairy farms was handled almost exclusively as a solid, the liquid wastes needed to be dealt with separately. In most cases the amount of liquid was low since wastewater from hand washing the milking machines was the largest contributor to the waste flow. There were no bulk tanks to wash and no parlors to hose down. The wastewater was usually flushed down a dry well, or sent straight out a pipe to a stream or road ditch or out onto the land. This may have been tolerated in the past because of the small quantities involved and the lower level of concern for the environment. Today these methods have a high potential to result in the pollution of surface or groundwater, especially with increased flows and more contaminants in the water.

With the introduction of septic systems for household wastes the same technology was used for milk house wastes. Waste from most milk houses is three to five times as concentrated as household waste. The large amount of organic matter in the milk house wastes is not degraded in the septic tank, and it keeps the leach lines of a septic system saturated and anaerobic. Milk fats degrading in an anaerobic environment in the leach line usually cause the line to seal up, forcing the wastewater to come to the surface in an uncontrolled manner. If sealing of the leach lines does not occur, it is often because the soil is so permeable that the wastewater leaches straight down to the groundwater with minimal treatment. This is no different than the effect of a dry well, and the potential for pollution is high.

Dairy farms that use both manure storage and liquid handling systems to apply manure to the land have usually included the milking center waste in this combined system. This is an efficient way to treat the milking center waste. The best way to treat milking center wastes as well as manure is to disperse them on the land at an application rate that meets the recommended nutrient amounts for the crop grown, and at a time when the crop will soon use the nutrients. When the waste is applied or incorporated in agronomically recommended amounts, the organic matter is broken down aerobically and converted into usable plant nutrients. Incorporating the waste into the soil reduces odor production, making this method more acceptable to neighbors.

Dairy, farms that have not converted to a liquid handling system with long-term storage or that choose to treat the milking center waste separately will need to consider other treatment systems. To determine which method is the most feasible, such systems need to be evaluated for cost, necessary management, treatment effectiveness, and suitability to the specific farm site. Professional help can be obtained from private agricultural consultants, especially agricultural engineers, or the local Soil and Water Conservation District, the Natural Resources Conservation Service, or the Cooperative Extension Service.

SECTION 2: WASTEWATER CHARACTERISTICS

Both the amount and concentration of milking center wastewater are variable from farm to farm and even from season to season on the same farm. Variations in the amount of water depend on the amount of water used to wash the cows' udders, the milking equipment, and the milking parlor; to precool the milk (when cooling water is disposed of); and to provide water softening back flush in some systems. Other additions to the volume can come from the disposal of wastemilk and manure left by the cows in the parlor or holding area. To help minimize the amount of water used and to reduce the size of the treatment system, the volume of wastewater can be reduced by reusing washwater to clean the floors, keeping cows' udders clean to minimize extra washing, using the correct amount of water for washing-equipment cycles, scraping manure out before using a hose to clean the parlor floor, and avoiding adding precooler water to the waste stream. Table 1 shows the ranges of water use common to milking centers. Milking more often than twice a day will add additional wastewater.

Estimating the Amount of Wastewater Produced

The work sheet allows one to estimate by several methods the amount of wastewater produced. In some instances the amount of water used can be determined by catching it in a container of known size. This is one way of calculating the volumes directly. Another way of calculating the volume is to determine the flow rate by directing the flow to a container and timing it and then multiplying that rate by the total time that flow is used. Sometimes the volumes of water used can be obtained from the manufacturer’s rating on equipment. An accurate way to determine actual water use is to borrow a water meter and install it for several weeks in the water line to the milking center.

The concentration of wastewater depends on the amount of dilution and the amount of contaminants added. If a liberal amount of water is used to wash down the milking parlor, or if all the precooler water is sent down the milk house drain, this can dilute an otherwise strong concentration by adding a large volume of clean water. Reducing the amounts of milk, manure, and feed that go down the drain can significantly reduce the concentration of the wastewater. Controlling the addition of milk to wastewater is especially critical. Milk has a five-day Biochemical Oxygen Demand (BOD_5) of 100,000 mg/1. This high BOD_5 makes treatment of wastewater with a large amount of milk very difficult. A high BOD_5 means that it takes a lot of oxygen to degrade the waste. With all the oxygen used up, the waste turns into an anaerobic environment accompanied by bad odors and slower treatment. It is important for the health of any waste-water treatment system to reduce the amount of milk going into it.

Manure has a BOD_5 of around 20,000 mg/1. While lower than the BOD_5 of milk, this is still high com-pared to household waste that has a BOD^ of 300 mg/1. The fibers in the manure are more stable and don't demand as much oxygen, as milk, but these solids do fill settling tanks and plug soil pores. It is important to keep the amount of manure in the wastewater as low as possible. Scraping the manure off the floor of the parlor to add it to the rest of the manure before hosing down the parlor floor will help prevent problems in the wastewater treatment system.

Table 1 Wastewater generation from washing

Washing Operation	**Approximate Wastewater Generated (units vary)**
Bulk tank	5 of bulk tank volume
Automatic	50-60 gallons/wash
Manual	30-40 gallons/wash
Milk pipeline[a]	75-125 gallons/wash
Milking system Clean-in-Place (CIP) (parlor)	12-20 gal/unit, four-cycle cleaning
Bucket milkers	30-40 gallons/wash
Miscellaneous equipment	30 gallons/day
Back flush	1 gallon/cow milked/milking
Cow prep	
Automatic	1-4.5 gal/cow-milking
Manual	0.25-0.5 gal/cow-milking
Wash pen	3-5 gal/cow-milking
Milk house floor	10-20 gal/day
Parlor floor (hose down)	50-100 gal/wash
Parlor floor and cow platform High-pressure or high-volume hose	500-1,000 gal/wash
Parlor and holding area floor with flushing	
Parlor only	20-30 gallons/cow-day
Parlor and holding area	25-40 gallons/cow-day
Holding area only	10-20 gallons/cow-day
or Automatic flushing	1,000-2,000 gal/wash

[a] Volume increases for long lines in large stanchion barns.

Sources: adapted from MidWest Plan Service, 1985; Reinemann and Springman, 1992.

Milking Center Wastewater Work Sheet

1. Bulk tank

manufacturer's rating

= ____________ gallons/wash

or measured amount

= ____________ gallons/wash

or 5% of bulk tank volume

= ____________ gallons/wash

or guess= ____ (3o-60) gallons/wash

=volume used ____________ gallons/wash

x ____________ washes per day

= ____________ gallons per day

2. Milking system CIP

Include prerinse (if included inwastewater flow), wash, acid rinse, and sanitize cycles. See DPC Guideline 2, *Guidelines for Effective Installation, Cleaning, and Sanitizing of Milking Systems.*

manufacturer's rating

= ____________ gallons/wash

or measured amount

= ____________ gallons/wash

or guess= ____ (75-300) gallons/wash

=volume used ____________ gallons/wash

x ____________ washes per day

= ____________ gallons per day

3. Milk house

3a. Bucket milkers

measured amount

= ____________ gallons/wash

or guess= ____ (3G-40) gallons/wash

=volume used ____________ gallons/wash

x ____________ washes per day

= ____________ gallons per day

3b. Milk house floor

measured amount

= ____________ gal!ons/wash

x ____________ washes per day

= ____________ gallons per day

or guess= ____________ (10-20) gallons/day

volume !Used = ____________ gallons per day

4. Parlor

4a. Cow prep (automatic)

manufacturer's rating

= ____________ gallons/cow-milking

or measured amount

= ____________ gallons/cow-milking

or guess= ____ (1-4.5) gallons/cow-milking

=volume used ____________ gallons/cow-milking

x ____ cow-milkings per day

= ____________ gallons per day

or cow prep (manual)

measured amount

= ____ gallons.'cow·milking

or guess= ____ (0.25-0.5) gaVcow-milking

=volume used ____________ gallons/cow·milking

x ____ cow-milkings per day

= ____________ gallons per day

or cow prep (wash pen)

measured amount

= ____ gallons/cow-m ilking

or guess= ____ (3-5) gaVcow-milking

=volume used ____________ gallons/cow-milking

x ____ cow-milkings per day

= ____________ gallons per day

4b. Back flush

manufacturer's rating

= ___________ gallons/cow-milking

or measured amount

= ___________ gallons/cow-milking

or guess = ___________ (1 gallon)/cow milked/milking

= volume used ___________ gallons/cow-milking

x ___________ cow-milkings per day

= ___________ gallons per day

4c. Parlor floor (hose wash-down)

measured amount

= ___________ gallons/wash

or guess = ___________ (50–100) gallons/wash

= volume used ___________ gallons/wash

x ___________ washes per day

= ___________ gallons per day

or parlor floor and cow platform with a high-pressure hose

measured amount

= ___________ gallons/wash

or guess = ___________ (500–1,000) gallons/wash

= volume used ___________ gallons/wash

x ___________ washes per day

= ___________ gallons per day

or parlor cow platform and holding area floor with flushing

measured amount

= ___________ gallons/flush

or guess = ___________ (1,000–2,000) gallons/flush

= volume used ___________ gallons/flush

x ___________ flushes per day

= ___________ gallons per day

4d. Manure produced in parlor and holding area

manure produced

= ___________ gallons per cow per day

x percent of time in parlor and/or holding area

______ percent of the day divided by 100

= ______

= ______ gallons of manure per day

– ________ gallons of manure removed by scraping or channeling

= ___________ gallons per day

5. Milk wasted

measured amount

= ___________ gallons/milking

or guess = ___________ gallons/milking

= volume used ___________ gallons/milking

x ___________ milkings per day

= ___________ gallons per day

6. Feed spilled

measured amount

= ___________ gallons/milking

or guess = ___________ gallons/milking

volume used ___________ gallons/milking

x ___________ milkings per day

= ___________ gallons per day

7. Cooling sprays

measured amount

= ___________ gallons/minute

or guess = ___________ gallons/minute

= volume used ___________ gallons/minute

x ___________ minutes per day

= ___________ gallons per day

8. Other water sources

measured amount

= ___________ gallons/milking

or guess = ___________ gallons/milking

= volume used = ___________ gallons/milking

x ___________ milkings per day

= ___________ gallons per day

9. Total wastewater, manure, milk, and feed entering the waste treatment handling system (total # 1–8)

= ___________ gallons per day

Table 2 shows average values for the waste characteristics of milking center wastes. These values will be different depending on the amount of water used and the amount of waste materials introduced. Both of these factors are within the control of the management on the farm. Ranges in the amount of wastewater produced per cow, as shown in table 2, and in the BOD_5 of the wastewater (400 mg/1 to 10,000 mg/1) demonstrate that these values can be controlled and reduced to a certain extent. Table 2 shows the increases in concentrations that occur when water from the milking parlor and especially the holding area cleanup is included in the wastewater system. Such differences in the concentration of the wastewater should be taken into account in selecting and designing the treatment system.

Table 2 Dairy waste characterization-milking center

Component	Units	Milk House Only	Milk House and Parlor	Milk House, Parlor, and Holding Area [a]	Milk House, Parlor, and Holding Area [b]
Volume	Ft^3/day/1,000#	0.22	0.60	1.40	1.60
Water volume	gal/day/1,400lb cow	2.3 [c]	6.3 [c]	14.7 [c]	16.8 [c]
Moisture	%	99.72	99.40	99.70	98.50
Total solids	% wet basis (w.b.)	0.28	0.60	0.30	1.50
Volatile solids	lb/1,000gal	12.90	35.00	18.30	99.96
COD(chemical oxygen demand)	lb/1,000gal	25.30	41.70	—	—
BOD_5	lb/1,000gal	—	8.37	—	—
N	lb/1,000gal	0.72	1.67	1.00	7.50
P	lb/1,000gal	0.58	0.83	0.23	0.83
K	lb/1,000gal	1.50	2.50	0.57	3.33

[a] Holding area scraped and flushed—manure excluded.
[b] Holding area scraped and flushed—manure included.
[c] These values may vary by up to 500.
Source: Soil Conservation Service, 1992.

SECTION 3: SOURCE CONTROL

An important part of the treatment of milking center wastewater is to reduce the volume of water and/or the amount of added material that will put stress on the system. At the same time that the treatment system is being planned, the generation of wastewater needs to be examined for potential reduction or elimination. The amount of wastewater can be managed, as is shown by the variability of both the flows and the concentrations shown in table 1 and table 2. Doing a proper job of source control on a farm will allow lower-cost treatment systems to be used successfully. For existing systems, less maintenance will be required and system lives will be extended. Energy savings for reduced pumping and water heating costs can also be expected.

Water reduction is critical for reducing the amount of wastewater both in the liquid handling systems and in the store and haul systems. Some manure handling systems use milking center water to help move the manure. If the water is not needed for this purpose, however, the volume reduced in the milking center on a daily basis can mean a significant savings as the material is transported throughout the farm for application. In one way or another, all treatment systems use the soil's capacity for wastewater infiltration. Reducing the total volume that the soils need to handle will improve their functioning. The methods shown in table 3 were identified by Springman (1992) as ways that the volume of water could be reduced.

Since the amount of milk entering the waste stream is the greatest influence on the BOD_5 of the waste, the need to reduce milk flows into a wastewater treatment system is vital. Mastitis control can play a large role in the amount of waste milk that must be handled. This is a good example of source control. Collected waste milk and prerinse water should be kept out of the wastewater treatment systems. It may be fed to animals under some conditions. Table 4 from Springman (1992) shows ways that milk can be removed from the wastewater systems.

Table 3 Water conservation methods for milking centers

Water Conservation Method	**Water Saving Potential**	**Estimated Cost [a]**
Use low-water cow propping Methods	High	<$300
Reuse pre-cooler water	High	$300-$1,200
Reuse acid rinse/sanitizer water to wash parlor floors	High	> $1,200
Install and tune air injectors	High	> $1,200
Manually rinse bulk tank	Low	<$300
Install milking unit cleaning manifold on pipeline systems	Medium	$300-$1,200
Install sink with water-saving design	High	$300-$1,200
Combine acid rinse and sanitizer CIP cycle	Low	<$300
Install booster pump for cleaning parlor floors	Medium	$300-$1,200
Scrape parlor floors before wash-down	Medium	<$300
Install floor slopes and drains to ease cleaning and reduce contaminants	High	> $1,200
Shorten CIP cycle after prerinse for milk removal	Low	<$300
Shorten CIP cycle after prerinse for milk removal	Low	<$300

[a]1997 dollars
Source: adapted from Springman, 1992.

Manure has a lower BOD^5 than milk, but it is still quite high when compared to domestic waste. Manure also has a high content of solids that can settle out and plug both pipes and soil pores. For treatment methods that use a settling tank, reducing the amount of manure entering the wastewater stream will reduce the number of times that the settling tank must be pumped as well as reducing the likelihood that the manure will pass through the settling tank and plug up or slow down the treatment system. Most of the manure reduction methods are related to management. Table 5 shows these reduction methods. Peed that is spilled when fed in the parlor can also add to the BOD_5 and solids problem. Whenever possible, feed should not be allowed to enter the waste stream when the wastewater will be treated.

In watersheds where phosphorus is a concern, reducing the amount of cleaners may be important. Using only what is needed to clean the systems and using low-phosphorus detergents can decrease the amount of phosphorus significantly.

Using automatic systems appropriately and water treatment where needed can be a cost savings. Table 6 shows ways that Springman (1992) identified that the phosphorus entering the waste stream can be reduced.

Not all of these methods are appropriate for every farm. Some are only feasible when constructing a new facility. All methods should be evaluated to see where improvements will pay off. Source control is an important part of the design and maintenance of a treatment system. Existing treatment systems that have failed can sometimes be revived with adequate source control. Once the BOD_5, nutrients, total solids, and volume of water are reduced, there is an opportunity for the biological and physical processes to keep up with the waste generated.

Table 4 Waste milk removal practices, potentials, and costs

Waste Milk Removal Methods	Removal Potential	Estimated Cost[a]
Prerinse manually	High	<$300
Prerinse CIP with or without diverter valve	High	< $1,200
Collect waste milk below transfer pump	High	<$300
Install ball check valve and provide sanitary air	High	> $1,200
Install waste milk floor drain in parlor pit	High	$300-$1,200
Install above-floor waste milk drain system on pipeline systems	Medium	< $1,200
Install collection sump with drain line on pipeline systems	High	>$300
Simplify pipeline system geometry by using flat barn	Medium	> $1,200

[a] 1997 dollars
Source: adapted from Springman, 1992.

Table 5 Manure reduction methods and costs for milking centers

Manure Reduction Method	Reduction Potential	Estimated Cost[a]
Schedule the cleaning of alleys and holding areas to minimize the amount of manure tracked into parlor	High	< $300 to > $1,200
Scrape the cow platforms before hosing down parlors	High	<$300
Don't install drains in the cow platform	High	> $1,200
Slope the floors of the parlor to facilitate scraping to the holding area	High	>$300
Install deep traps in drains	Low	$300-$1200
Keep traffic from manure areas out of the milk house	Low	<$300

[a] 1997 dollars

Table 6 Phosphorus reduction methods and costs

Phosphorus Reduction Method	Reduction Potential	Estimated Cost[a]
Install water softener and/or increase softening time	High	< $1,200
Install an iron filter if needed	Low	<$300
Install automatic, programmable CIP dispensing system	Medium	> $1,200
Use low-phosphorous detergents and acid rinses or those with no phosphorous	High	<$300
Reuse CIP detergent and/or acid rinse water	Medium	>$300
Install water conservation methods in CIP	Medium	>$300

[a] 1997 dollars

Source: adapted from Springman, 1992.

SECTION 4: THE MILKING CENTER DRAINAGE SYSTEM

Codes and Regulations

Local or state health codes will usually dictate that wastewater from the toilet room and employee comfort area be handled according to domestic sewage disposal regulations. The cost of a septic tank leach field or other domestic sewage disposal system is usually higher than typical milking center wastewater disposal systems. Therefore, connect to these systems only those drains or appliances that must be handled as domestic sewage.

In addition to disposal requirements as dictated by the Pasteurized Milk Ordinance, state milk production regulations, and state or local sewage disposal codes, many farms come under the control of state or local plumbing codes (BOCA 1990). These codes may have more stringent requirements concerning piping materials, installation methods, gas traps, and vent lines than are discussed in this guideline. It is the responsibility of anyone designing or installing a milking center drainage system to be knowledgeable about and conform to all applicable codes.

Component

Components of a milking center drainage system include sloping floors, collection gutters, and curbs that direct water to drains. Drain outlets or openings, traps, drainpipes, vents and cleanouts are also part of the collection and drainage system. In some cases, collection sumps and pumps to elevate wastewater or holding tanks and pressure pumps to allow reuse of wastewater will also be included. Base selection and installation of drainage system components on the specific needs of each milking center.

Floor Construction

Durable, hard-surfaced floors are necessary in all parts of the milking center. The most common material is concrete with various finish textures, such as troweled, brushed, incorporated grit, or grooved, with the selection of texture depending on use, slope, and traffic type (animals or people). Do not scrimp on concrete quality or care in placement when installing milking center floors. Shortcuts in quality or careless placement will result in daily problems with difficult cleanup, water ponding, and deterioration. Various industrial tiles or epoxy coatings are also used in areas where deterioration caused by milk or detergent streams may be severe. The drainage path from milk tank valves and wash sink or receiver drains should receive special attention. Special floor coatings and well-defined, short paths to drain inlets are recommended. When possible, we recommend direct piping to the drainage system from wash sinks. Approved traps, vents, air gaping, or other back-siphon prevention steps are necessary to assure separation between the potable water system, milking system, and drainage system.

Floor Slopes

It is important that the milk room drains be located and the floor sloped to provide rapid drainage of water off the floor. A slope of ½ inch per foot, or 5 inches per 10 feet, will help prevent ponding where there is less-than-perfect concrete finishing. At a minimum, slope floors ¼ inch per foot, or 2 ½ inches per 10 feet. The minimum slope should be used only when it is possible to maintain a very uniform surface and slope. To prevent ponding around a drain, recess the drain opening ½ to 2 inches below the floor elevation.

Drain Placement and Type

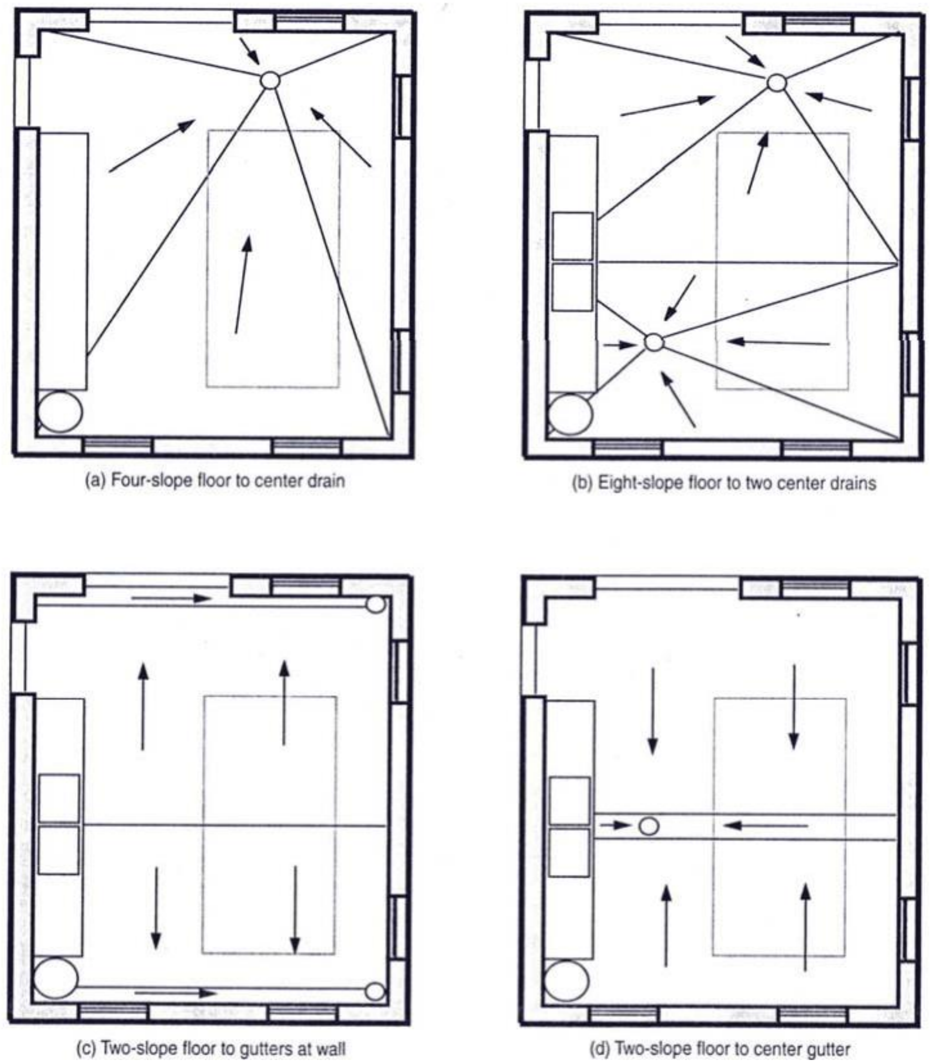
Light (1980) proposed several ideas to improve the functioning of floor wash/drainage systems in milking centers. Most of his suggestions are still valid in today's milking centers. His main conclusion was that gutters, with or without grates, were preferred over individual drains to allow for easier concrete placement and easier wash-down (figure 1).

An individual point drain for a rectangular area requires successful installation of four triangular sections of sloped floor, all flowing to the drain (figure l.a and b). Lack of a suitable screeding support at the drain end of these sections complicates this procedure. Depending on placement, a gutter across a room requires one or two rectangular floor sections sloped to the gutter (figure l.c and d). The edge of the gutter provides an easy-to-use guide for concrete screeding that can help make the gutter the lowest point of the room.

During wash-down, it is easier to chase debris and water into a gutter or comer drain than into a point drain in the middle of the floor. Gutters located along one or more sides of a room are often preferred over gutters in the center of a room.

Low curbs, thresholds, or floor elevation differences can be used to prevent washwater from escaping from one room or area into another. To minimize tripping hazards for people or animals, use such differences in floor elevation with care. Avoid curbs, thresholds, or gutters across openings or lanes where cow move- ment is critical. These items will cause cows to slow down and observe the obstruction before passing and may injure the cows' feet, legs, or low-hanging udders. In addition, grates that may cover gutters provide unsure footing and may be uncomfortable for cows to walk and stand on.

Figure 1 Floor wash/drainages systems



(a) Four-slope floor to center drain

(b) Eight-slope floor to two center drains

(c) Two-slope floor to gutters at wall

(d) Two-slope floor to center gutter

Source: R. G. Light, 1980.

Gutter Sizing and Type

Gutters can be described in terms of width, depth, and whether they are covered with grates. Wide gutters (more than 8 inches) will contain more water, and high-velocity water flows are less likely to overshoot them. Grates are usually installed over these gutters. Wide gutters less than 2 inches deep may be left open if not in a high-traffic area. Grates with thin vertical bars provide more opening for manure to slide through but are more uncomfortable for cows to stand on. More manure will accumulate on flat bar grates, but they are more comfortable for the cows. Use round bars only where cows or humans will never be expected to stand. An angle iron or other wearing surface installed along the gutter for the grate to rest on will eliminate concrete wear and provide a more stable grate. Wide gutters can be formed from concrete or made from preformed stainless steel, of plastic gutter sections, or of large PVC pipe split in half. Narrow gutters (2 to 6 inches) are often used as perimeter drains along walls of milk rooms and parlors. Overshooting of water is not possible because of the wall. Such gutters may be formed as part of the concrete floor by using two wedge-shaped pieces of lumber cut to provide the desired gutter width (2 to 6 inches) and sloped bottom. Grease the pieces and anchor them to the form board or outside wall. Position the pieces so that the top forms a surface to which the concrete can be screeded. Slope gutter bottoms 1 inch per foot to the drain. Small-diameter PVC pipe can be slit in half and used to form small gutters around the perimeter of a room. Holding pipe sections in position during concrete placement can be a problem.

Materials, Drains, and Pipes

Schedule 40 PVC or ABS. DWV pipe and fittings work well for milking center drains. This material is easy to work with, has a smooth, easy-flowing interior surface, resists attack from acids, and is heavy enough to withstand the normal abuse of installation, backfilling and concrete placement. Using less durable pipe for drainage systems that will be buried beneath concrete floors is not recommended.

Drainpipes should have a minimum slope of Vs inch per foot. Higher slopes will increase scouring velocity. Milking center wastewater contains small, easily settleable solids that will fall out and plug pipes if liquid velocity is too slow. Large-sized solids are normally not present in milking center wastewater flows.

Use 3- or 4-inch-diameter pipe to connect individual drains to the main drain line. Size sink or other appliance drain lines based on drain outlet size and anticipated discharge rate and quantity. Main drain lines can be 4-, 6-, or 8-inch diameter, depending on the volume of flow. Too large a pipe in relation to anticipated flow rate can result in insufficient scouring and settling out of solids particles. This is especially true in pipes with a low slope.

If flush tanks are used to flush parlor or holding area floors, larger diameter lines or large collection gutters and sumps may be necessary to assure that water and manure solids do not back up onto the floor.

Install traps and vents to assure that gases from enclosed sumps, collection tanks, or manure storages cannot flow back into the milking center. Use full-flow, deep water seal-type traps to minimize plugging problems and assure that a water seal is maintained (figure 2). Bell trap drains where the seal consists of a ridge (on the bottom of the drain cover plate) that protrudes into a shallow rim of water in the drain are not satisfactory (figure 2). Heavily used drains often have the cover plate removed, but this practice defeats the purpose of the trap. In drains that are not regularly used, the shallow water seal will evaporate, resulting in no water seal. The number of traps required can be minimized by directing several floor or gutter drains to a single drain gutter with a trapped and vented drain that is connected to the main drain line. In small milking centers it is often possible to have one trapped drain in the comer or end of the operator area of the milking parlor, with all other floor drains discharging into this drain.

Install cleanouts to allow access to areas where plugging may occur. For long runs of pipes, locate cleanouts to allow convenient access for rodding equipment (figure 2).

Drainage Systems for the Milking Center

Collecting and handling the various wastewater materials generated within the milking center and directing them to appropriate disposal are important aspects of milking center design and construction.

Milk Room Drains

The drains in the milk room must handle milking equipment and bulk tank washwater, hand sink washwater, and general floor wash-down. When planning drain placement in the milk room, consider the locations of equipment with a wastewater discharge, of bulk tank and bulk tank outlet, of doors, and of expected pedestrian traffic flow. *(See Guidelines for Milkrooms and Bulk Tank Installations, DPC 41,* for specific requirements.) Slippery floors can result from standing water in low spots, the flow of soapy water across pedestrian paths, and the flow of water in front of doors that let cold outside air flow across the floor.

Two common alternatives for floor drainage provide reasonable assurance of well drained floors. One method is to install a crowned floor with open gutters along opposite sidewalls. This system requires a drain in each gutter or a gutter along a third wall that allows flow from all gutters to a single point (figure l.c).

A second method to drain the milk room floor is to locate a gutter across the center of the milk room floor (figure l.d). The center gutter provides a place to support screed boards for maintaining proper slope on the floor surface. If the gutter goes under the bulk tank, there must be sufficient clearance for cleaning and inspecting the gutter. Slope the bottom of the gutter to a drain that is not located beneath the bulk tank. The shorter the path from the bulk tank outlet to a drain the better. An acid-resistant surface on the floor between the bulk tank outlet and drain will reduce floor deterioration. A small area of tiles, glazed concrete blocks, or epoxy coating, or a flat piece of stainless steel can provide protection.

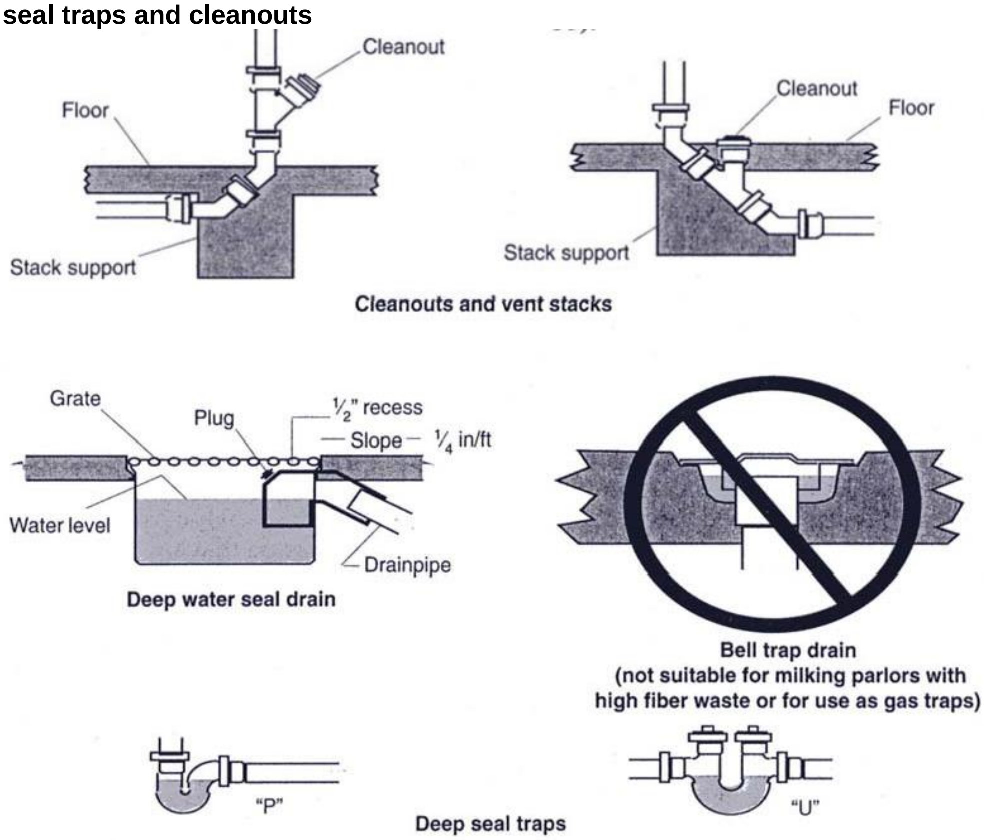
Piping sink drains directly into the drain line will prevent the flow of this water across the milk room floor, minimize wet, slippery floors, and eliminate deterioration of concrete surfaces from detergents and milk. If a gutter is located under the sink, a simple drop pipe can direct the water into the gutter and minimize splashing and cross-floor flow.

If the milk room floor is higher than the milking parlor operator area, the milk room drain can serve as an inexpensive "signal" to workers in the parlor that milk is running onto the milk room floor. Direct the drainpipe from the milk room through the side of the wall near the drain. If milk is flowing down the drain it will soon be seen by the operators.

Cow Platform Drainage System

When selecting a drainage system, consider the floor-washing method and the handling of manure and foot dirt from the parlor platform and the holding area. Parlor platform cleanup may involve either scraping all manure to the holding area for removal by tractor-scraper before wash-down or washing all manure down the drain with a hose or flushing system. Parlor platform cleaning may also be combined with the holding area cleanup. In the simplest system, all manure from the parlor is flushed or hosed into and through the holding area along with the holding area manure. A modification would involve scraping manure from the holding area and then washing or flushing the floor as part of the parlor cleanup procedure. If it is desired to keep manure solids out of the wastewater, a platform with a solid floor and no gutters is easiest to hand scrape. The cleaning method selected affects the size and placement of drains and gutters.

Figure 2 Deep seal traps and cleanouts



Source: The Pennsylvania State University

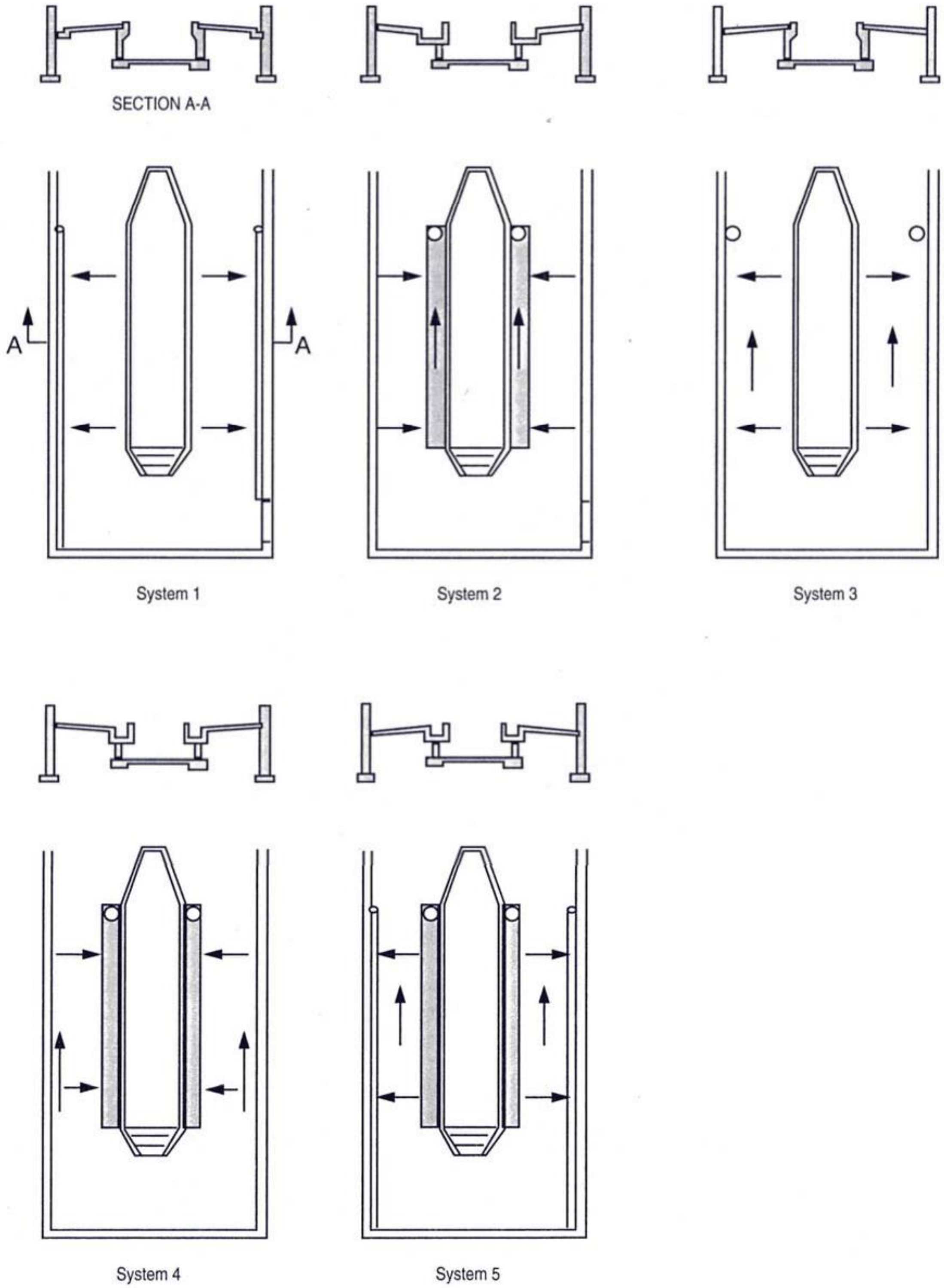
In a herringbone parlor, a gutter parallel to and next to the curb serves to collect manure and urine during milking and to reduce splashing. This gutter also may slow down cow entrance and exit, as cows usually avoid walking on grates when possible. In a parallel parlor, gutters along the edge of the platform are normally not installed, because a manure collection gutter mounted on the back rail is designed to catch manure and urine, and because cows do not like to stand with both feet on the gutter grates. In side-opening parlors, it is common to place a drain at the rear of each stall to catch manure and urine from cows standing to be milked.

Cleanup of occasional manure piles during milking is easier if the manure can be hosed away from the operator. This is difficult if the only drain is between the operator and the manure deposit. Drain placement in parlors that are washed separately from the holding area can be a problem. Placing a drain gutter between the holding area and the parlor will prevent washwater from flowing into the holding area. However, placing a gutter across the entrance to the parlor will slow down cow entrance traffic and is not recommended.

Several different drainage systems can be used. These different systems employ three alternative floor slopes:
1. Cross slope from operator area toward wall.
2. Cross slope from the wall to the operator area
3. Slope along the length of the parlor platform, usually toward the cow entry point

Different drainage systems can be designed using combinations of the above three floor slopes, depending on parlor management techniques desired (figure 3).

Figure 3 Milking parlor platform drain systems



Source: adapted from R. G. Light, 1980

System one: The cow platform is level along its entire length and has a cross slope to a shallow, open gutter along the outside wall. The gutter bottom slopes to a drain either at the center or at one end of the platform. This design allows easy removal of manure from the platform by scraping, and the operator can easily hose down the platform while standing in the operator area.

System two: The cow platform is level along the length and has a cross slope from the wall toward the pit to a grate-covered gutter parallel to the pit wall. The gutter bottom slopes to a drain. With this design, manure and urine splatter is minimized during milking. Solids that are in the gutter at the end of milking are usually washed down the drain. The grates can be removed and manure shoveled out, but this is an undesirable chore that is usually not done.

System three: The cow platform slopes toward the cow entry end and has a cross slope to the pit wall. The drain is placed in the comer at the cow entry end. A gutter may be placed along the wall to direct the water to the drain. This design allows manure to be washed away from the operator during milking, and manure can be easily scraped from the platform after milking or hosed to the drain.

System four: The cow platform slopes toward the entry end of the parlor and has a cross slope from the wall to a constant-depth gutter parallel to the pit. This gutter either has a drain at the entry end or is simply allowed to come to the surface in the holding area. Washwater from the parlor flows through the holding area. This system does not work well if water must be kept out of the holding area. Early designs placed a collection gutter between the parlor and the holding area. This gutter interferes with cow traffic into the parlor and is not recommended. A modification is to slope the platform towards the front end of the parlor where a gutter along the wall can collect the washwater.

System five: The cow platform may be level along its length or slope to one end of the parlor. A gutter with grates is located along the pit. The platform slopes away from this gutter to the outside wall, where a small gutter collects water and manure from the platform. This design provides a gutter behind the cows to minimize splatter but also allows manure to be washed away by the operator.

Careful planning can limit the number of trapped floor drains in the milking parlor (figure 4). The pit floor drain can be made the principal drain and include a deep water seal trap. Platform drains can be simple drop pipes and elbows that discharge above or next to the pit collection drain. Because these drains are not directly connected to the main drainpipe or enclosed sumps where gases may form, no traps or vents are required. If the holding area is to be flushed, parlor platform gutters can simply extend into the holding area and be positioned so as to meet the surface as the holding area slope is increased.

Holding Area

Water and manure from holding areas that are flushed with water from flush tanks or hosed down with large-capacity fire hoses must be collected and drained away. In some systems where all animal areas are flushed, the holding area may discharge into a cow traffic lane that also serves as a collection channel for flush water. Sometimes a drop dam across the back of the holding area is placed so as to accumulate water and then be dropped to flush the cow lane. This system is often used in conjunction with wash pens. When selecting a floor surface for the holding area, consider the floor-cleaning method that will be used.

To collect the washwater and manure at the back of the holding area, a cross-collection gutter is required. This gutter and its drain must be large enough to hold the volume of flush water that is expected with one flush or to carry away the volume of water discharged from the fire hose. If there is insufficient elevation for gravity flow from the gutter to the storage area, the gutter should discharge into a sump with a solid-handling sump pump. With flush systems, a gutter at least two feet wide may be necessary to prevent the high volume of manure and water from flowing over the gutter. This is especially a problem when the gutter must have grates on which cows can walk.

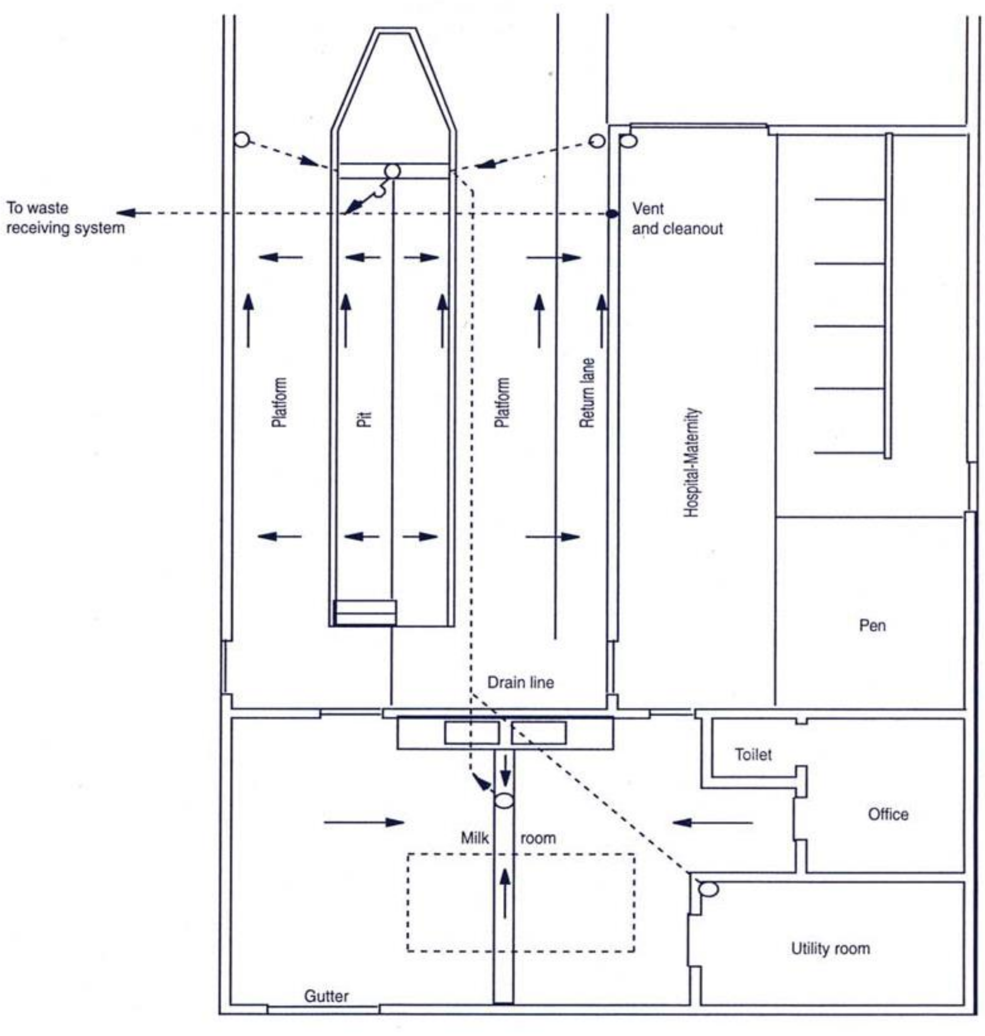
Operator Area Drainage System

The methods for collecting washwater in the operator area are to slope the floor to one end or to both sides. The technique of placing a crown in the center of the area and sloping the floor to small gutters along each sidewall provides two advantages. It is easy to direct water towards the gutters on either side of the area.

Also, a 1 ½-inch crown in a pit floor that is 6 to 7 feet wide helps the operator to "lean into" the cows during milking, since the floor slopes toward the cow (Bickert et al 1995). The entire floor of the operator area can also be sloped to a collection gutter across one end or the other. Sloping the floor from either end towards the middle is not recommended because the cross gutter becomes an obstacle to foot traffic during milking. Also if the operator area floor slopes differently than the cow platforms, the access height will vary. The operator area floor is usually sloped to maintain a consistent relationship to the cow platform. Gutters along the sides can be sloped in either the same direction as the floor itself or the opposite.

If the receiver assembly is to be located in the operator area, consider the discharge of milky and soapy water from this unit during cleanup. This material will deteriorate concrete surfaces, so protect the concrete or extend drain hoses to empty into the drain or gutter.

Figure 4
Milking center drainage system using one deep waster seal trap



Source: R.G. Light, 1980.

Utility and Storage Rooms

The design and placement of drains in utility and storage rooms should take into account situations such as oil and grease leakage from machinery, problems from floor debris being washed under equipment, and storage of water-sensitive boxes or other material. The use of strategically placed gutters, built-up equipment platforms, and separate drains for water softeners are a few of the practices to consider. Take precautions to assure that traps in drains that will have infrequent use do not dry out and expose the room to the potential flow of gases back into the room.

Good Milking Center Drainage Systems

Milking center drainage systems perform an important day-to-day function in making a milking center a safe, productive, and comfortable work location for cows and workers. They also are essential to the production of clean, quality milk. Drainage systems start with selection and installation of proper floor slopes and surfaces that direct washwater and debris to gutters and drains. Floor slopes and surface conditions affect the comfort and mobility of both cows and workers. Installing gutters improves the chances that floor slopes will be successfully installed, and gutters are more effective than point drains in capturing debris being hosed across a floor surface. Piping systems need to be designed and installed in an economical manner, and must provide functional operation and conform to good plumbing practices and regulatory requirements. Good systems incorporate plans that provide easy cleaning of gutters, sumps, and pipes. Design and installation of a milking center drainage system require appropriate input from the milk regulatory agency for the farm and in some cases from local or state plumbing code authorities.

A good drainage system will minimize the amount of water needed for cleaning and may include subsystems that allow reuse of water for more than one purpose. Additional steps can be taken to minimize wastewater flow by selection of efficient equipment and operation methods. Systems may be required to handle only floor wash and milking equipment washwater or to also include manure deposited in holding areas and hospital areas and water generated by wash pens and specialized equipment. The best system is the one that works, while requiring the least amount of thought or action on the part of the workers.

SECTION 5: TREATMENT ALTERNATIVES

There are various ways to treat milking center waste- water. Each method may have advantages and disadvantages in site-specific situations. These methods include adding the milking center wastes to the liquid manure handling system, storage for subsequent land application separately from the manure handling system, grass filter strips, aerobic lagoon, organic filter bed, standard septic system with a leach field, constructed wetlands, stone-filled treatment trench, spray irrigation, treatment by lime flocculation, and aerated septic system. Table 7 shows some of the differences between each of these alternatives. Costs are typical for the milking center wastewater treatment for 100-cow operations.

Each of these treatment methods utilizes the land as the final sink for the wastewater. For each system, the potential for runoff of untreated wastewater and/or the leaching of pollutants to the groundwater needs to be evaluated for the specific concerns at each location. As a general rule, the greater the area that the wastewater will ultimately be spread over, the less the potential to pollute. The more opportunity there is for exposure to oxygen for aerobic decomposition, the less likely it is there will be an odor problem and the more rapidly the wastewater will be treated. Soil contact is also desirable. Soil particles are a good medium for bacteria. These organisms can use the potential pollutants as an energy source. This is the main way that the wastewater is cleaned. Table 8 shows a comparison of other site-specific factors to consider in selecting a system. All of these systems will be constrained with the presence of bedrock or a high water table. Areas are based on a 100-cow system producing 400 gallons of wastewater a day.

Each of these systems can fail from mismanagement. It is better not to place these systems in hydrologically sensitive areas, so that if a problem occurs the untreated or only partially treated wastes won't be able to flow quickly downstream or directly into an aquifer. Hydrologically sensitive areas include areas next to watercourses, in groundwater recharge areas, or on ground that is often saturated. These areas have a high potential for delivering pollutants to places of special environmental concern. If these areas cannot be avoided on a specific site, a more conservative design and more management attention would be appropriate.

Liquid Manure System

Liquid manure handling is becoming more common. This is because less bedding is being used, especially in freestall operations; higher-producing herds excrete wetter manure, and average production per cow is increasing; more systems are being installed in which water is used to flush floors; and there is increased storage of manure in earthen storage ponds, which results in about 30% additional volume due to rainwater. If a liquid handling system already exists on the farm, the milking center wastewater can be added to the system for just the additional cost of the extra storage and the hauling and application. There is no better way to treat milking center wastewater than to apply it at agronomically correct rates over a large land area. Microorganisms existing in the soil over time degrade the waste into plant-usable forms, effectively treating the waste.

The extra storage needed to accommodate the milk house wastewater can be estimated or measured for each farm. This volume will need to be increased because as the storage volume increases, the surface area will increase, catching more precipitation. With the time required for storage known, the additional rainfall from the extra surface area needed for the milking center wastewater storage can be determined. The increase in volume to account for rainwater is around 30%. If a more expensive storage structure is needed because the site is not suitable for an earthen storage pond, the cost of storing the wastewater increases. In that case it may be cheaper to use an alternative treatment method to avoid expensive long-term storage of the milking center wastewater.

Table 7 Comparison of treatment methods

Treatment Alternative	**Cost in Thousands of Dollars [a]**	**Management Considerations**	**Pollution Potential**
Liquid manure system	1-2	If a liquid system is present, the extra water may improve its function. $0.005 per gallon to apply.	If applied following a good nutrient management plan, there is very low chance of a problem.
Short-term storage and land application with manure spreader	1-2	Storage system must be emptied when full. Additional handling and application equipment may be needed. $0.005 per gallon to apply.	If applied following a good nutrient management plan, there is very low chance of a problem.
Grass filter	2-4	Grass needs to be established before use. Resting the filter strips by rotation or dosing is needed.	Filter strip can cause groundwater and runoff pollution under adverse conditions.
Aerobic lagoon	4-8	Lagoon needs to be filled with water before use. Lagoon needs to be emptied occasionally.	If the effluent is applied following a good nutrient management plan, minimal pollution potential exists.
Organic filter	3-8	Organic material will need to be renewed occasionally. System designed to resist freezing.	Leaching to the groundwater is a potential problem.
Septic system	2-5	Lines will plug in most soils within five years	Leaching to the groundwater is a potential problem.
Constructed wetlands	3.5-10	Wetland plants need to be established before use and maintained.	If the effluent is applied following a good nutrient management plan, minimal pollution potential exists.
Stone-filled treatment trench	5-8	System designed to resist freezing.	Leaching to the groundwater is a potential problem.
Spray irrigation	4-6	Higher pressure pumps and nozzles have maintenance problems. System not designed to resist freezing.	Spray area can cause groundwater and runoff pollution under adverse conditions.
Lime flocculator treatment	1-4	First flush needs to be diverted. Small amounts of lime needed,	Limited pollution potential with disposal.
Aerated septic system	2.5-5	Reliable aerator needed.	Leaching to the groundwater is a potential problem.

[a] Costs in thousands of 1997 dollars are ranges for a 100-cow dairy

The addition of the milking center wastewater may be a benefit to certain handling systems. There is a dramatic decrease in the energy needed to pump manure slurries as the moisture content increases. Some gravity flow systems and some pumps will not move manure without the addition of water. Adding the milking center wastewater at a strategic location can help to liquefy the manure slurry enough to make these systems successful without increasing the total wastewater flow on the farm.

Application of the wastewater with the manure on the farm's cropland to treat the wastewater and provide nutrients for the crops does cost money. An efficient hauling and application system costs approximately $0.005 per gallon. Table 2 shows the nutrient content of typical milking center wastewater. Assuming that each nutrient costs $0.25 per pound and that each nutrient is needed on the field and retained for plant use, 1,000 gallons of typical milk house and milking parlor wastewater has 5 pounds of nutrients, or $1.25 in nutrient value. The application cost of 1,000 gallons is about $5. Of course the actual slurry is much more nutrient-rich when taken to the field, since it is mixed with the manure.

Table 8 Comparison of factors to consider in selecting a treatment system

Treatment Alternative	**Soils**	**Area**	**Slope**	**Climate**
Liquid manure system	Costs increase if earthen liner is unsuitable.	2,300 extra square feet of surface area in storage pond.	0-8	Storage time is dependent on length of the wet and frozen period.
Storage and land application	Short-term storage in structure	Buried structure uses minimal space.	Any	Pumping in freezing weather can be a challenge.
Grass filter	Excessively drained soils have potential for groundwater pollution.	Two filters 20 feet wide by 100 feet long and outlets 300 feet from watercourse.	At least 2%	Frozen soils may cause runoff concerns in the spring melt.
Aerobic lagoon	Low-permeable soils needed.	From 0.6 acres to 0.8 acres including the dike	0-4%	Size increases as temperature decreases.
Organic filter bed	Moderate permeability, but not excessively well drained	3,000 to 6,000 square feet	0-4%	Will function well in cold climates.
Septic system	Moderate permeability, but not excessively well drained	90 to 230 linear feet of trench 10 feet apart	Leach lines run on 1% slope	Will function well in cold climates until leach lines plug.
Constructed wetlands	Low-permeable soils needed.	4,000 square feet and outlet 300 feet from watercourse through a filter strip	0-2%	Increasingly large area is needed as temperature decreases.
Stone-filled treatment trench	Moderate permeability, but not excessively well drained	640 linear feet of trench, 10 feet apart	Trenches run on 0.5-1%	Will function well in cold climates.
Spray irrigation	Not excessively well drained	4,000 square feet	0-12%	Will not work in cold climates.
Lime flocculator treatment	Works well in all soils.	10 by 10 feet inside, and 180 feet of leach line	Leach lines run on 1% slope	Treatment area must be kept from freezing.
Aerated septic system	Moderate permeability, but not excessively well drained	90 to 230 linear feet of trench	Leach lines run on 1% slope	Will function well in cold climates.

[a] Areas are based on a 100-cow system producing 400 gallons of wastewater a day

<u>Short-Term Storage and Land Application with Manure Spreader</u>

Installing a storage structure and providing a pump as shown in figure 5 and using a liquid-tight manure spreader to land apply the wastewater can be done on all sites at a price. It can be used when the soils near the bam, or other constraints, don't allow another treatment method. The treatment occurs as the waste-water is applied and soaks into the soil. This method is often the alternative of last resort because of the expense of providing a storage structure and pump and the cost of continual operation. Nevertheless, when the wastewater is applied over the whole farm it can be spread thinly and thereby avoid building up high nutrient concentrations in any one spot. Since the storage structure will need to be emptied during wet or frozen weather, there is always the potential for runoff or leaching problems.

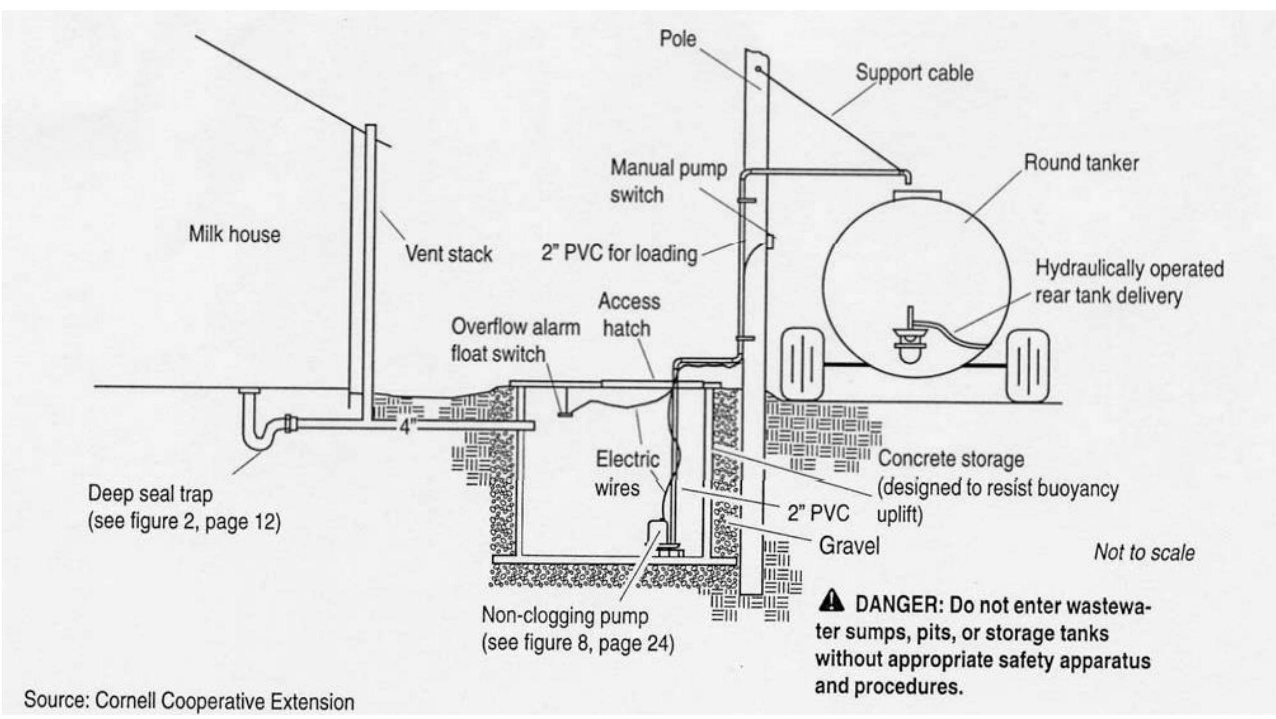
The storage structure, whether above or below ground, concrete or metal, needs to be selected and installed carefully. Aboveground tanks need to be protected from freezing, damage from collisions, and leakage. Underground tanks need to be able to withstand the earth pressure without collapse, to be strong enough for any external loading from heavy traffic, and to resist buoyancy forces when the tank is pumped out and the soil surrounding it is saturated. The bigger the tank, the less often it has to be emptied, but the more it costs to construct or to purchase and install.

While manholes for access are needed, they must restrict access to avoid accidents. *The gases that can build up in enclosed tanks can kill quickly.* Use extreme care whenever entering an enclosed waste-containing area. Use a self-contained breathing device and have the means and manpower to be able to be pulled to safety if necessary.

The pump required to unload the tank should be a high-volume, low-head pump that can handle the grit and other solids that will be in the waste stream. Submersible trash pumps will likely meet these criteria. If the storage time in the tank is more than three days, an agitating method may be needed to keep solids from building up in the tank. Another option is to provide an elevated tank and to pump the wastewater up as it is produced and then to use gravity to empty it.

Applying the wastewater can be done with any liquid handling equipment (figure 5). Borrowed or rented tank spreaders are a good alternative. Liquid fertilizer tanks mounted on truck beds or trailers can be used as long as field access can be assured. Small amounts of milk house wastewater can be applied daily by loading fairly solid manure on the back of a box spreader and then adding the liquid waste. However, this method will make it harder to apply the manure as evenly as a fertilizer should be applied.

Figure 5 Milk house short-term storage for land application

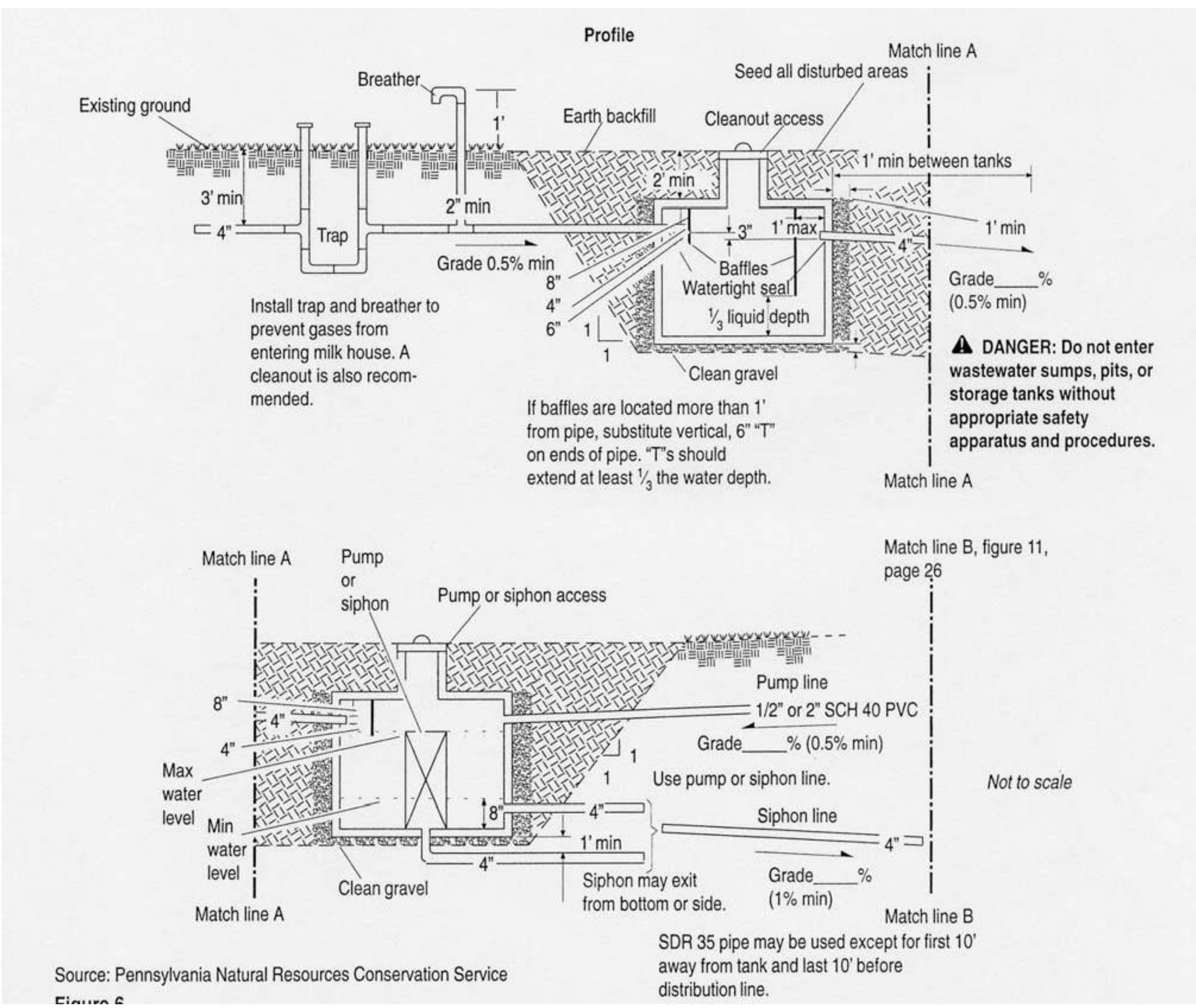


Settling Tanks

Each of the remaining treatment systems uses a concentrated area for treatment. By establishing favorable conditions for microorganisms, such treatment systems allow increased biological activity to reduce the concentrations of potential pollutants in a smaller area. These systems work best if the amount of solids entering the treatment system is limited. The solids contain a large portion of the biodegradable material in the wastewater. Including them may overload the system. The solid portion will interfere with efficient pump operation, plug pipes and soil pores, and take up space within the treatment system. A settling tank providing three days' retention of the liquid waste is recommended in order to allow settleable solids to drop out and to prevent floating manure fibers and fat cake from the milk to be passed on.

The design considerations for the settling tank are much, like those of the holding tank described earlier. The inlet of these tanks should be vented to prevent gases from backing up into the milking center. The wastewater should enter and leave below the floating layer and above the settled layer. This can be accomplished by installing both the inlet and outlet tees set vertically. The upper part of the tee can be used for access if plugging occurs. Baffles will also work and are shown in figure 6.

Figure 6 Settling tanks with pump or siphon for milking center wastewater

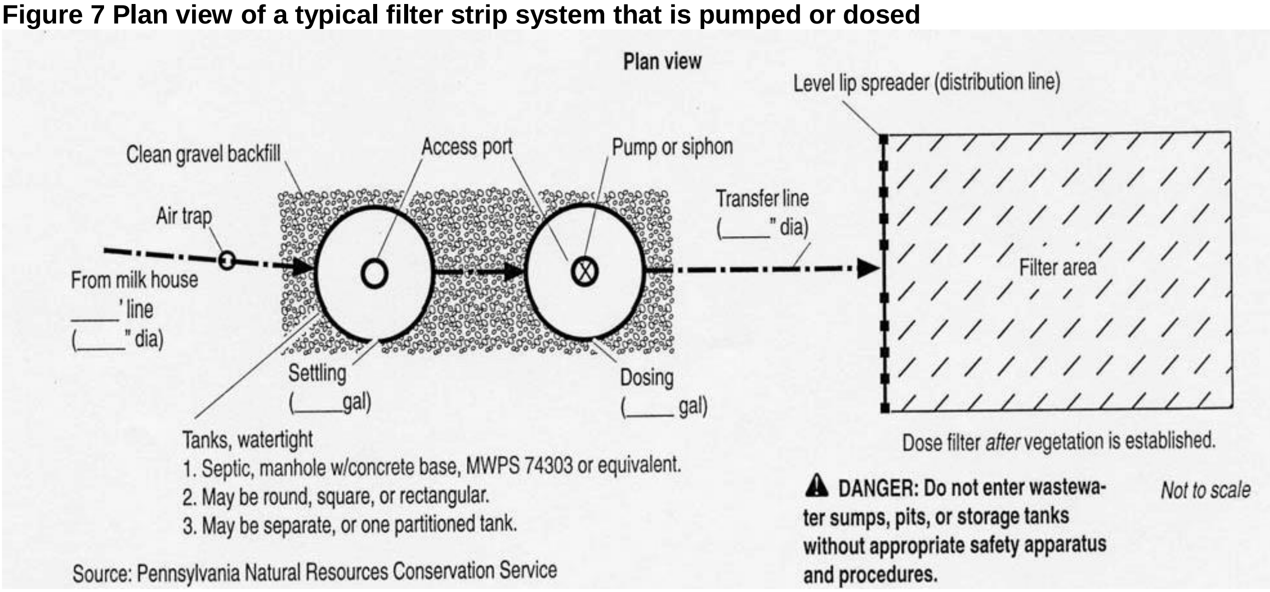


The draw-off level of the outlet tee in the settling tank needs to be two-thirds of the way down from the surface of the tank. Manure contains many floatable fibers that when combined with milk waste and mixed with water separate and float readily to the surface. These floating solids are also capable of messing up the next stage of the treatment system. Typically the settling tanks from a milking center where manure is added to the waste stream need to be pumped out monthly, although frequency depends on the management and specific layout on each farm. Cows that regularly walk on dirt or mud can bring in more dirt that settles to the bottom. Scraping manure out of the milking parlor prior to wash-down is an important way to prevent rapid solids buildup in the settling tank. Although it is different on all farms, settling tanks from only the milk house need to have the solids removed just once or twice a year. This can be done using the same operations as those used for pumping out domestic septic tanks.

Where a pump or siphon is used to move the liquid on to the next stage of treatment, a separate pumping tank is used to avoid agitating the material that has settled to the bottom or floated to the top. Figure 7 shows a plan view of a typical filter strip treatment system that is pumped or dosed. Figure 8 shows a typical pump tank, and figure 9shows a typical siphon tank. The pump tank should be sized for efficient pumping. Choose a pump tank large enough so the pump turns on no more than seven times a day. If the pipeline drains back into the pump tank, the pump tank should be sized so that the volume of water drained back is no more than one-fifth of the total tank volume. A light that indicates a full tank or a pump failure can help prevent equipment malfunction from becoming an environmental headache.

Gravity flow from these settling tanks is the easiest way to get the wastewater to a treatment system. Four-inch, SDR 35 PVC pipe on a 1% or steeper grade works well. When gravity flow is not possible, small submersible pumps with a 1 ½-inch-diameter pipe can deliver the wastewater satisfactorily. The pipes need to be protected from heavy loads if they cross travel ways. Pumped systems need to be designed to be drained after each use or to be installed deep enough to avoid freezing. Cleanouts should be provided as necessary, especially where wastewater will sit in the pipe for long periods or where deposits of milk fat, soap scum, and other substances are likely to build up in the pipelines over time.

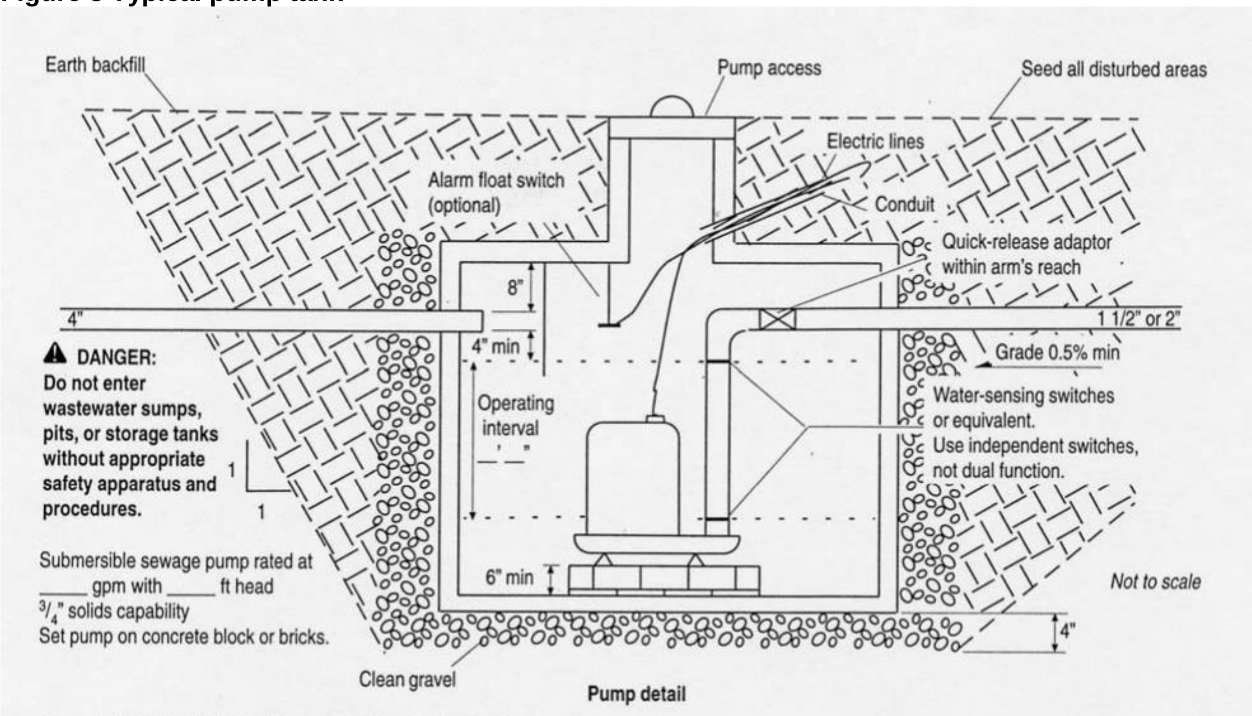
Figure 7 Plan view of a typical filter strip system that is pumped or dosed



Grass Filter

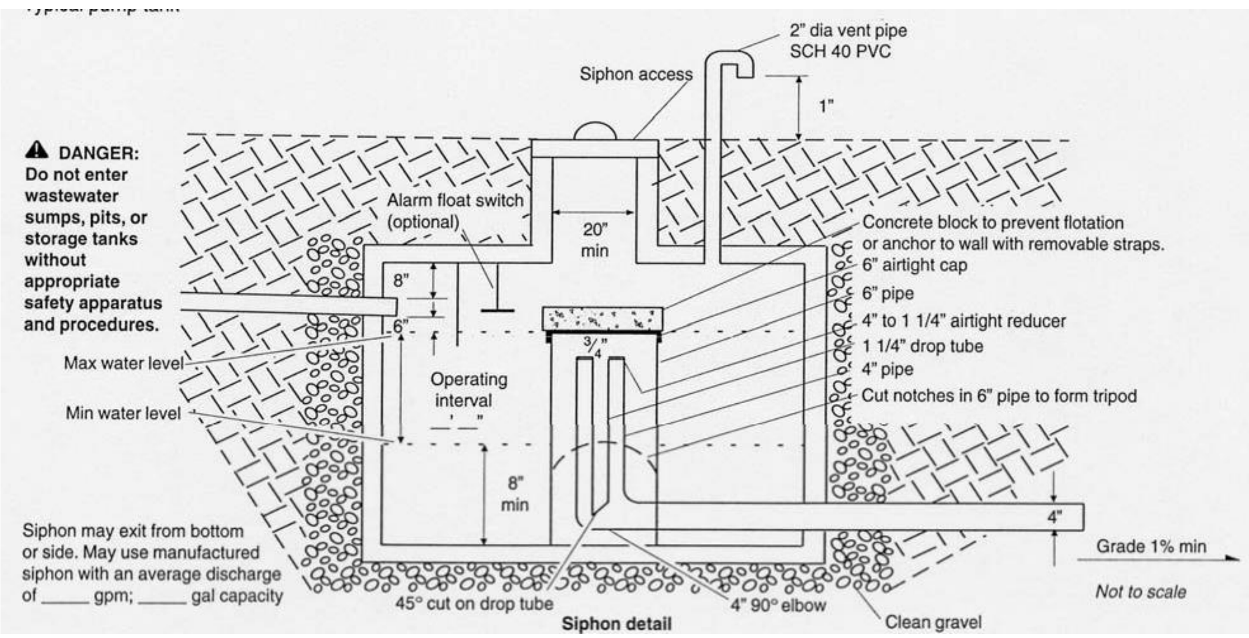
Grass filter strips are a viable alternative on most farms. The wastewater flow needs to be run through a settling tank, as described above, before being sent to the filter area. Spreading wastewater out on a well-vegetated surface is an excellent treatment method. A grass filter strip can be located on most farms and installed relatively cheaply. An appropriate spreading device at the entrance of the filter strip is necessary to provide an even flow. The filter strip does need occasional maintenance. Operating two filter strips by resting one while loading the other is essential for the health of the grass. A typical system is shown in figure 10. On small farms, dosing with a siphon system or a pump tank that allows three days' storage is another way of resting the filter strip. Figure 7 shows a plan view of this kind of system. Figures 11 and 12 show two additional views of a filter strip system that works best when wastewater is applied quickly in a relatively high-volume surge.

Figure 8 Typical pump tank



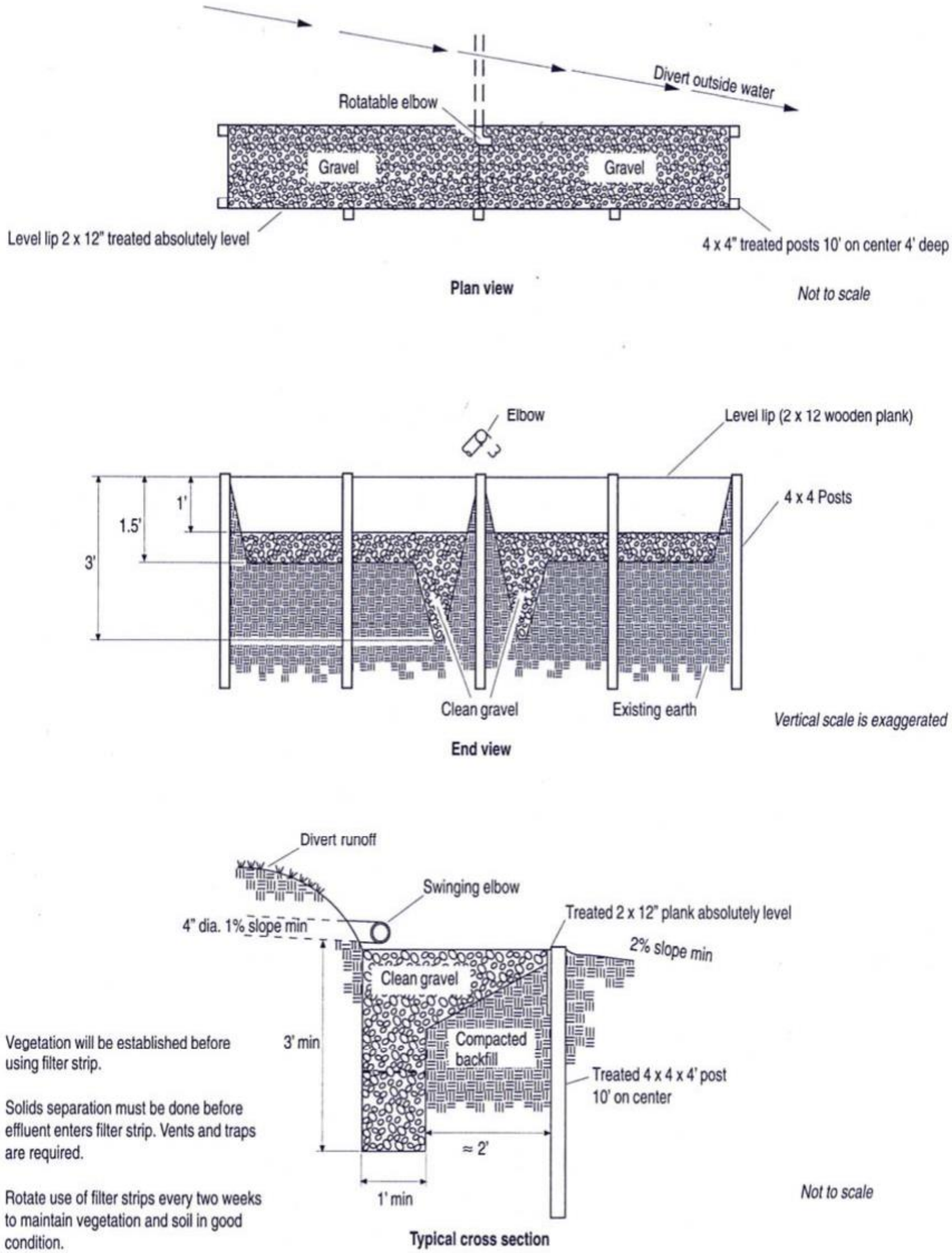
Source: Pennsylvania Natural Conservation Service

Figure 9 Typical siphon tank



Source: Pennsylvania Natural Resources Conservation Service

Figure 10 Plan, end, and cross-section views of filter strips that allow resting

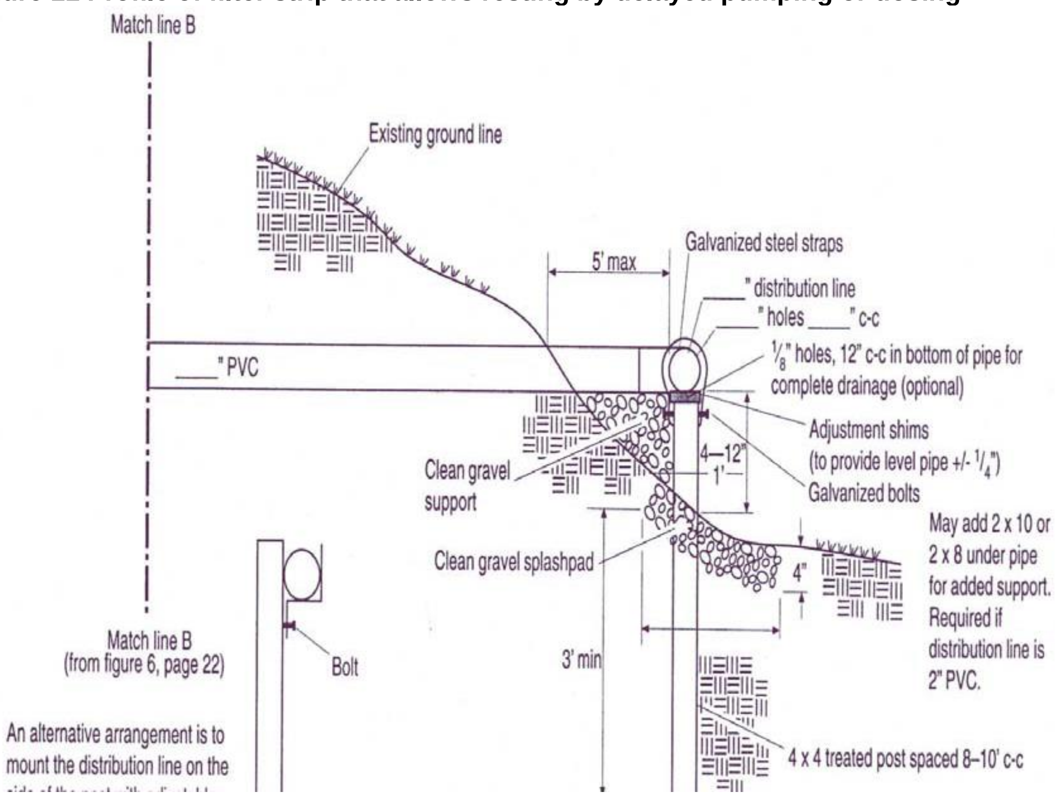


Source: New York Natural Resources Conservation Service and Cornell Cooperative Extension

Most biological activity in the ground occurs in the topsoil layer. This is the activity the filter strips are relying on to degrade the waste. Oxygen, sunlight, and microorganisms are excellent inputs to any aerobic treatment method. The wastewater has a chance to infiltrate slowly over a wide area and also to be filtered as it flows though the sod. The bacterial activity in the filter strip is aerobic and will be odor-free for the most part. In addition to bacterial action, soil adsorption of nutrients, evaporation of some water, and physical filtration occur. Because both infiltration and surface flow are possible, if there is a short circuit through the grass filter, there is the potential for pollution of either downstream surface water or groundwater. Highly permeable soils may allow the wastewater to leach downward without treatment. Low-permeability soils, soils plugged with solids, saturated soils, or frozen soils may allow the wastewater to run off the filter area without treatment occurring.

Grass filter strips need to be well vegetated before they are stressed by the addition of wastewater. Adding wastewater too soon to a newly established stand will prevent the grasses from forming the dense sod that is best for the treatment of the waste. Often it is better to look for existing vegetation that can be used than to prepare a filter area by land forming and then seeding. Ten square feet of filter area is recommended for each gallon of wastewater produced each day. Slopes of more than 2% will move the wastewater away from the spreader and down onto the rest of the filter area. The vegetation should be dense sod-forming grass. Reeds Canary Grass, Tall Fescue, or Creeping Red Fescue are often recommended. Reeds Canary Grass is hard to establish. A mix of seeds is better, as there will likely be moisture and nutrient differences down the length of the filter strip and a combination of grasses can perform better under inconsistent conditions. Because of the risk for groundwater contamination, filter strips should be at least 100 feet from wells. The outlet of the filter strip should not lead directly to a watercourse but be directed to a field or diverted onto a grass waterway for about 300 feet. The grass filter strip needs to be protected from upstream surface runoff by a berm on the upstream end.

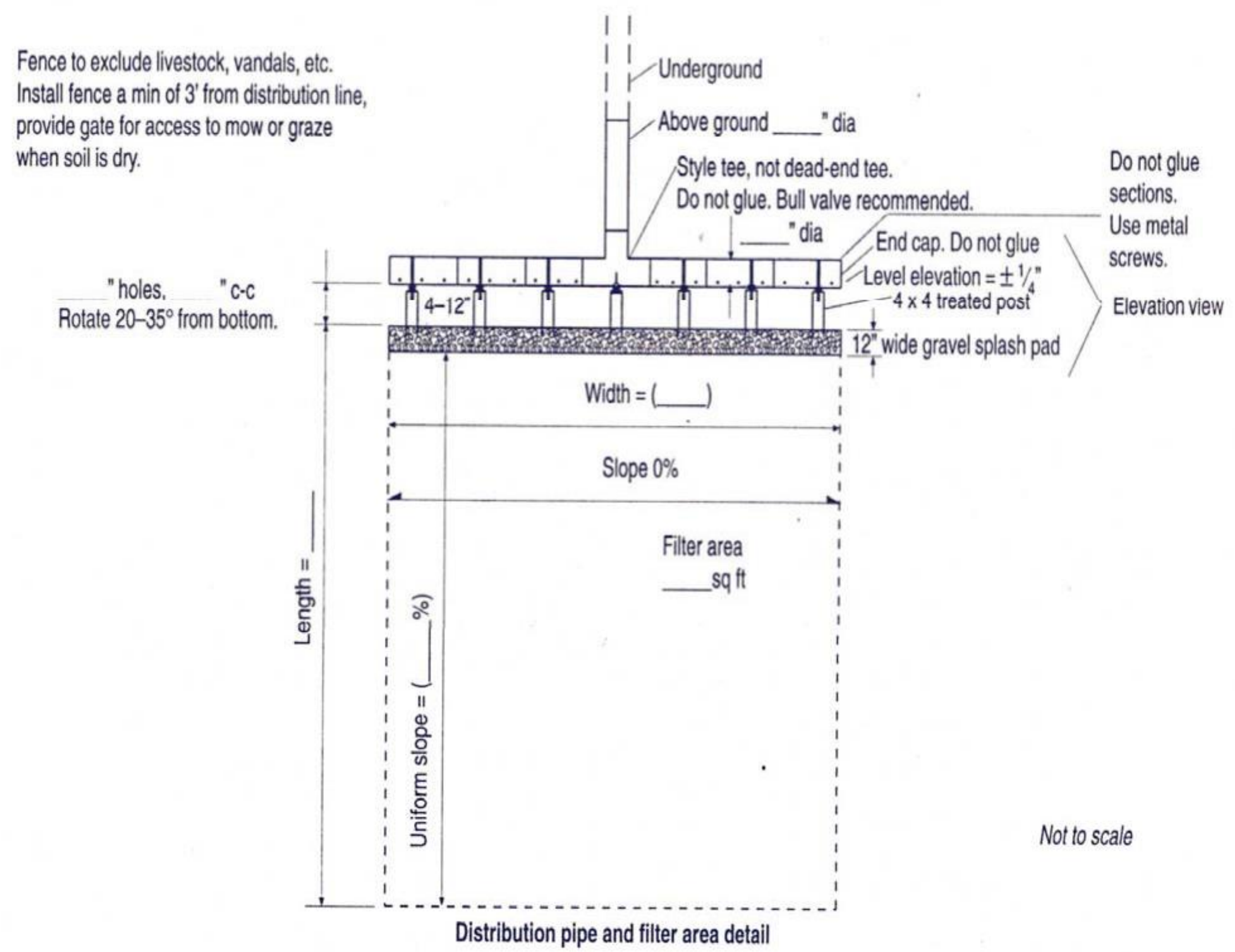
Figure 11 Profile of filter strip that allows resting by delayed pumping or dosing



Source: Pennsylvania Natural Resources Conservation Service

Although the cost to install a filter strip can be quite variable, it is often one of the cheaper methods of treatment. If an existing vegetated area is used, the largest expense is for the spreading device. The best spreading method is to dig a trench perpendicular to the slope, fill it with clean gravel, and then install a treated board spreader on the downstream side of the trench. The board can be set level and then backfilled with earth to make the wastewater flow over it evenly. These spreaders allow some infiltration in the gravel trench as they distribute the water across the slope. An earthen trench cannot be built even enough to get good spreading. If concrete spreaders don't spread evenly, they are not adjustable. Gated pipe spreaders need maintenance to keep the holes distributing effluent evenly. Dosing will tend to keep these holes open. The gravel trench with wooden spreaders can be installed with farm labor to keep the costs down.

Figure 12 Plan view of distribution pipe and filter area of filter strip that allows resting by delayed pumping or dosing



Source: Pennsylvania Natural Resources Conservation Service

Spreaders more than 20 feet long are not likely to spread the wastewater evenly. Adding more filter strips instead of making a bigger one allows the filter strips to be rested as the wastewater is rotated from one to another. This rest is essential to keep the vegetation healthy and to let the soil aerate. Wastewater flows of more than 400 gallons a day will need to have three or more filter strips. Maintaining this rotation should not be neglected. A second gravel-filled trench located 25to 50 feet down the filter strip can help to redistribute flows which have been concentrated. It is unusual for visible flow to go beyond this second trench.

Aerobic Lagoon

An aerobic lagoon treats the wastewater by supporting microorganisms in the volume of water in the lagoon. Oxygen is provided by sizing the surface area, where gas is exchanged, to meet the BOD_5 requirements of the waste. These systems need a relatively large area. The partially treated water cannot be discharged directly to a watercourse. The effluent needs to be land spread. Aerobic lagoons produce little odor and may be appropriate where earthen storage is possible and separate handling of the effluent can be done easily. Figure 13 shows a cross section of an aerobic lagoon.

Aerobic treatment depends on receiving the needed amount of oxygen from the surface and maintaining the temperatures that the microorganisms need to degrade the waste efficiently. The treatment area needed ranges from 45 pounds BOD_5 per day per acre in Virginia to only 25 pounds BOD_5 per day per acre in Maine. The warmer the climate the more likely this treatment alternative will be cost-effective. Sizing is similar for anaerobic lagoons (smaller size for warmer climate) but anaerobic lagoons are generally impractical north of the Mason-Dixon line. Aerobic lagoons may have some anaerobic activity in the deeper levels of the lagoon but should remain relatively odor-free, except for a short time in early spring and late fall when the water layers in the lagoon turn over.

Aerobic lagoons don't need much management, but there are some things to consider. The soils at a proposed lagoon site need to be evaluated to make sure that they are relatively impermeable. A hydraulic conductivity of 1×10^{-7} centimeters per second on the bottom and the sides is adequate. To start the aerobic process, the lagoon needs to be filled with water to a depth of two feet before wastewater is added. Solids separation with a settling tank is needed unless the lagoon is sized for the extra BOD_5 the solids bring in and there are provisions for removing the solids from the lagoon when they build up. To keep the lagoon mostly aerobic, the water level in the lagoon should not be allowed to exceed 5 feet. A fence should be provided to keep animals and people out of the lagoon.

The aerobic treatment can reduce the concentration of pollutants significantly, but not to the point that the effluent from the lagoon can be discharged directly to a watercourse. The water level in the lagoon will need to be lowered once per year because the wastewater addition and the precipitation will amount to more than the evaporation off the surface area. Lowering the water level in the lagoon can be accomplished by spray irrigating the effluent onto a field during the growing season or by releasing the effluent slowly from an outlet pipe, making sure that the flow soaks into the ground before it gets to a watercourse. The spray irrigation may benefit the crop, both providing water and to a small degree acting as a nutrient source. Releasing the water out of the outlet pipe should not cost anything but management time.

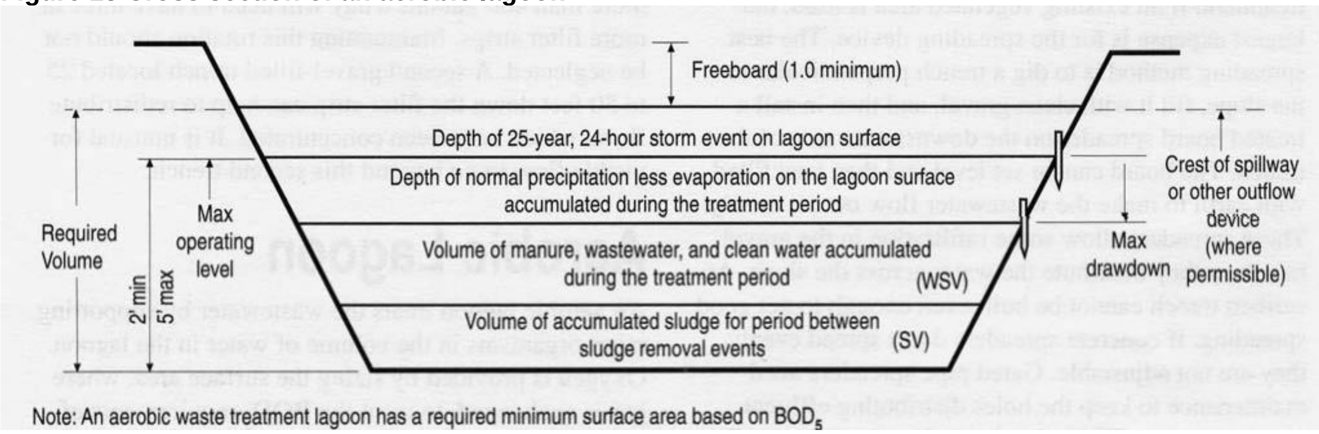
Organic Filter Bed

In cold climates a vegetative filter strip may not function well because the soil surface will freeze, even under a snow layer. The lagoon sizes needed in colder climates make them more expensive. Septic systems with leach lines that plug are not considered long-term solutions to milking center wastewater problems. A surface-applied wastewater treatment method was sought that could function well in cold weather. Organic filter beds are designed based on the area needed to infiltrate 1 inch of wastewater per week. A perforated pipe is used to distribute the wastewater over one end of this flat area. A low berm is formed around the area to contain the waste. This area is then covered with enough high-carbon organic material to prevent it from freezing. Sawdust, wood or bark chips, or straw can be used.

If sized properly, these systems work well. The organic material acts as a biofilter to keep objectionable odors trapped in the bed. The organic material is slowly decomposed as bacteria use it for a carbon source to break down the wastewater. The organic material will need to be renewed as it decomposes. This may be as often as every three years. The treated wastewater soaks slowly into the ground. Highly permeable soils should not be used with this method, as untreated wastewater may flow directly to the groundwater. Organic filter beds should not be located within 100 feet of a well because of this possibility. This system will not work well if solids or excess milk are allowed into the filter bed.

The cost of these systems will depend on the number of gallons of wastewater to be treated, the permeability of the soils, the earthwork needed to prepare the bed, and the cost and amount of organic material needed. If the soils are tight, more area will be required to infiltrate the water. If the site for the organic filter bed is on sloping land, more earthwork will be needed to prepare a flat area and build the berms around it. The amount and cost of the required organic matter can have a big effect on the total price of the system. The organic matter needed for a typical 100-cow dairy is 300 cubic yards of material. This is based on a 4,000-square-foot surface area with an average depth of 2 feet. If this material had to be purchased for $10 per yard it would cost $3,000. Renewing the organic material every few years will be an additional expense.

Figure 13 Cross section of an aerobic lagoon



Source: United States Department of Agriculture Natural Resources Conservation Service

An organic bed can also be used where minimal infiltration of the wastewater is desired. A small 3-foot-deep organic bed is placed in an area of relatively impermeable soil to reduce the BOD_5 and ammonia content of the waste before it enters a grass filter strip. High-porosity bark or wood chips work best in this application. An outlet and distribution pipe can be placed so that the 6 inches of wastewater is ponded in the organic bed prior to flowing to the filter strip.

Septic System

Septic system failures were discussed earlier. Septic systems are a temporary solution to the wastewater treatment problem. New leach lines can be installed as the existing ones plug in order to continue using the solid-separation part of the system. Dosing the lines or resting them long enough for the soil to drain and to allow aerobic activity may be a way for them to function as an acceptable treatment system. Although septic systems are still installed to handle milk house wastewater, treating wastewater anaerobically 2 feet underground is not a very effective method of reducing pollutant risk. If the soil is highly permeable, the lines may not plug but may pass the untreated wastewater down to the groundwater. Because of this possibility, these systems should not be installed within 100 feet of a well.

The one advantage that leach lines have, that they are underground and out of sight, contributes to the neglect of maintenance of the system. It is easy to forget to pump out the settling tank. If solids get past the settling tank and into the leach lines, the lines will become plugged. The anaerobic liquids will be forced to the surface, causing odors and flowing downstream, potentially to pollute.

Constructed Wetlands

Recently there have been some constructed wetlands installed to treat milking center wastes. A loading rate of 60 pounds of BOD_5 per acre per day has been proposed. Since this is a higher loading rate than that for aerobic lagoons, some savings in land area and cost were anticipated. The constructed wetlands were designed with a solid settling tank ahead of the wetland to remove solids that could overload the wetland and fill it too quickly with solids that will need to be removed. The wetlands do provide treatment to the wastewater. However, the quality of the effluent exiting the wetland at this high loading rate is variable, and even under the best treatment conditions is not suitable for direct discharge to watercourses.

The wetlands treat the wastewater aerobically in the surface water and anaerobically in the sludge in the bottom. They do not produce objectionable odors. The wetland plants provide more sites for the bacteria to cling to as they digest the waste. The plants also can add some oxygen to the microenvironment at the root hairs that may help breakdown the organic matter in the wetland. Dead plants may provide a better medium for the bacteria to thrive on than live plants. Except for the aesthetic benefits of constructed wetlands, it might be better to fill the shallow ponded areas with high-carbon organic matter and provide treatment the way organic filter beds do.

Like aerobic lagoons, wetlands are constructed on impermeable soil. Most are designed to be shallow ponds in series. The concentration of pollutants decreases as the wastewater flows toward the end of the system. Depths as shallow as 6 inches are recommended. The bacterial action is temperature dependent, so less treatment is provided in winter. It has been proposed to alternate some wetlands between shallow aerobic ponds to increase mineralization of ammonia, then route the wastewater flow into a deeper anaerobic pond to denitrify the nitrogen. Before final discharge, effluent from the anaerobic pond is directed to another shallow aerobic wetland to further treat ("polish") the effluent. Wetlands are still experimental, and appear to offer no advantages in cost or treatment effectiveness over aerobic lagoons or grass filter strips.

Stone-Filled Treatment Trench

Agricultural engineers in the Province of Ontario have developed a treatment method that works better than the traditional septic system for fairly permeable but not highly permeable soils. The system augments leach lines by widening the trenches and backfilling the bottom of the trenches with clean gravel. This provides more soil area for the water to infiltrate. The clean gravel provides an aerobic environment for the treatment of waste. The underground system works well in cold weather. Because of the possibility of wastewater flowing down into the groundwater without treatment, this system should be at least 100 feet from wells. This system costs more than the traditional septic system, milk it will provide treatment for the long term.

One to 2 ½ feet of trench is needed for each gallon of wastewater produced per day. The trenches are constructed about 3 feet wide and filled 2 feet deep with the gravel. Regular earth backfill is placed on top of the gravel. Fabric is used to separate the soil backfill from the gravel. The 4-inch perforated sewer pipe conducting the wastewater runs at a 0.5% grade near the top of the gravel. Perforations in the pipe are half-inch holes located in the upper half of the pipe, not drain tile slots that will plug. Pipe perforations are turned up so that the wastewater outlets halfway up the cross section of the pipe to better distribute the waste-water. Lines are limited to 100 feet in length to provide an even distribution to the trench.

Spray Irrigation

An irrigation system that spray irrigates the wastewater onto a crop field or grass filter area has been tried on a few farms. Farmers were attracted to this option by the potential to automatically distribute the waste onto a fairly large area without involving the spreader system that typical grass filter systems use. The irrigation system could be designed to load different areas so that the areas receiving the wastewater could be rotated to allow land to dry up for field operations or to let the crop or soil recover from constant irrigation. The high cost of this system, as well as poor functioning in the winter, make this alternative less than desirable for most applications.

Finding both spray nozzles that won't freeze and pumps that work under these conditions is a problem. Some rubber nozzles manufactured in Europe do not freeze during winter weather, but these are no longer imported. The angle of application of rubber nozzles could not be set to spray only one side of the irrigated area, so as to alternate irrigation areas. Consequently, to rest an area required a second irrigation system with valves to shift operation from one area and system to the other. American-made metal nozzles that were designed to not freeze were apparently not designed for the cold weather of upstate New York. The need for sufficient pressure to get a good pattern from the spray irrigation and the need for a pump that could handle some solids meant that a more expensive pump was required. It had to be housed in a separate pump house because it was not submersible, and below the elevation of the pump tank so that it could be self-priming.

Lime Flocculator Treatment

Borrowing from conventional wastewater technology, scientists in Ontario have created a system that treats milk house wastewater. This treatment system is used on the wastewater stream after the first flush has been separated. The part of the wastewater that contains most of the milk is retained and fed to the calves. About 3 pounds of lime is added to 400 gallons of wastewater, which is then mixed for twenty minutes and allowed to settle for two hours. The lime flocculates the milk and soap solids, which then settle and leave the rest of the water almost free of suspended solids. The clear water on top of the settling tank is then released to a leach line. The bottom 30 gallons of concentrated waste is released to the gutter to be disposed of in the manure stream.

This system concentrates the material that would plug the leach lines and adds it to the regular manure handling system. Less than one-tenth of the flow is added to the manure, and this amount can be soaked up without making the manure too watery. With only the treated water being sent to the leach line, there is very little chance that the leach line will fail since there will not be the usual biological reactions as the treated water enters the soil. The water may be recycled for some on-farm uses.

About a dozen of these systems have been successfully installed in Quebec and Ontario in the last two years. The inflows, lime additions, mixing, and effluent releases have been automated. This treatment will not remove suspended manure solids. Although some manure solids are removed, the effluent from milking centers where significant manure is added will need to be further treated. The tank and equipment need to be housed in a heated building to prevent freezing. The actual cost of the treatment components for the system can be low, but if existing space for the system is not available, the additional cost of building will increase the total cost.

Aerated Septic System

Installing a mechanical aerator in the septic tank of a traditional septic system and leach field has been very successful for restaurants with fatty wastewater. Although it has not yet been tried in a milking center wastewater treatment system, it should work. There are aerators that will deliver 0.875 pounds of oxygen per hour, with a power use of 3 kWh per day. Assuming an electric cost of $0.08 per kW, this aerator could provide the oxygen to treat the milking center waste- water from a 100-cow dairy for $90 per year. The aerator costs around $400 and should be easy to install. This treated wastewater would have much less potential to plug the leach lines. Alternating the leach lines to allow them to aerate could also help make this a viable system.*

Safety

! As with managing all systems on the dairy farm, care must be exercised to prevent accidents. Wastewater systems require specific measures to prevent asphyxiation or drowning. Dangerous gases can build up in enclosed spaces. These gases can kill without warning. Do not enter enclosed waste-handling tanks without ventilating them completely, or without wearing self-contained breathing equipment.

People and animals must be protected from accidental drowning in liquid storage areas. Covers, fences, and signs should be used to prevent people and animals from falling into these areas.

Health Concerns

Do not mix human waste in with these systems. Follow health department guidelines for treating human waste.

Keep waste that is exposed to the surface far enough from the milking centers to avoid contamination by flying insects.

* The Pennsylvania Department of Agriculture no longer approves the use of a septic system for the disposal of milking center wastewater. An acceptable alternative to subsurface disposal must be used for new milking centers or for repairs to existing septic systems.

SECTION 6: CONCLUSIONS

Although there are a number of treatment systems now available to the modem dairy, and some more potential systems, there is no perfect system.

Source control is essential in planning or maintaining a treatment system. This needs to be considered as the treatment system is selected and designed.

Planning and design are needed to make collecting and delivering the wastewater to the treatment system easy and efficient.

For dairies that have an existing liquid handling system for their manure, adding the milk house wastewater is a good treatment option. Farmers planning to install a liquid-handling system for the manure should consider including the milking center wastewater.

Of the other treatment systems, the grass filter system has low costs and small area requirements and provides good treatment in most conditions. In colder climates the stone-filled trench or the organic filter bed would be the recommended choices. The aerated septic system or the lime flocculator treatment may be a good choice for small flows in critical watersheds. There may be reasons to use the other treatment methods in specific situations.

Whatever system is chosen, the need for maintenance is key. No system is guaranteed to work if no attention is given to it.

Plan ahead if expansion is in your future. The reason most milking center treatment systems fail is that they are being loaded at greater than the design rate.

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ABOUT THE DPC

The Dairy Practices Council (DPC) is a nonprofit organization of education, industry, and regulatory personnel concerned with milk quality, sanitation, and regulatory uniformity. The objectives of DPC are to 1) develop and disseminate educational guidelines directed to proper and improved sanitation practices in the production/processing of milk and the manufacture of dairy products and 2) facilitate the adoption of sound, uniform, and improved procedures related to the production, processing, and distribution of high-quality fluid milk and dairy products. The intent of these objectives is not to duplicate but to cooperate with, other organizations that have similar educational and unifying goals. For more information, contact the DPC at daiypc@dairypc.org or visit the web site at: https://www.dairypc.org.

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NRAES, the Northeast Regional Agricultural Engineering Service, is a program focused on delivering engineering-related educational materials and training opportunities in support of northeast cooperative extension. All NRAES activities are guided by faculty members from northeast land grant universities.

NRAES began in 1974 through an agreement among the cooperative extension programs in the Northeast. The program is guided by the NRAES Committee, which consists of a representative from each northeast state and the District of Columbia as well as the NRAES director and an administrative liaison appointed by the Northeast Cooperative Extension Directors Committee. NRAES was housed in the Department of Agricultural and Biological Engineering at Cornell University.

NRAES changed its name to Natural Resource, Agricultural, and Engineering Service and eventually became part of Cornell Plant and Life Sciences Publishing (PALS). NRAES in any form is no longer active. This Document is no longer available from PALS

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