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Wastewater Pond Design and Construction
Technical Guidance Document WMS 18-04-2

This bulletin presents design and construction information about wastewater ponds for sanitarians, contractors, owners and others. Operation, maintenance and repair needs for wastewater ponds are presented in another bulletin.

Two types of private on-site treatment systems are in general use in Kansas — septic tank-soil absorption systems, and wastewater stabilization ponds or lagoons. In sandy or loamy soils, the septic tank-soil absorption system is the best choice. Where soil is clayey with poor drainage and adequate space is available, **wastewater ponds** are often the best alternative for treatment and disposal.

Wastewater ponds are typically comprised of the following features:

- A small fenced water body, with a three- to five-foot liquid depth, receives private residential sewage.
- Actual size is determined by number of occupants, size of home, amount of wastewater, rate of evaporation and soil type.
- Sewage enters the pond from a pipe below the water surface but above the pond's bottom, near the center of the pond.
- It must be non-discharging (meaning no overflow), so water can be disposed of by percolation and evaporation.

A wastewater pond is among the least-expensive on-site treatment options, and maintenance is not excessive. A pond should be the first consideration for wastewater systems where soils have severe limitations for soil absorption systems, but are well suited for pond construction, and there is enough area available to meet separation distance requirements.

How Wastewater Ponds Work

A wastewater pond is a nutrient-enriched living ecosystem. Bacteria and other microorganisms consume oxygen as they feed on nutrients in the sewage. The bacteria and microorganisms give off carbon dioxide, which in turn is used by algae. A wastewater pond's water is usually bright green because of the algae. The algae consume the carbon dioxide and produces much of the needed oxygen for the bacteria and other microorganisms. Oxygen also enters the wastewater as air blows across the pond surface.

Ponds have no offensive odor when properly sized, carefully constructed, well operated and routinely maintained. Sewage is broken down by microorganisms into water, gasses and residual solids, which settle and accumulate in the pond. Although odor from a good pond is rare, when it occurs it is usually because the living ecosystem has been upset. Upsets can be caused by chemicals that disrupt the natural system, organic overload from highly concentrated or too much waste, or accumulation of too much sludge. Extended cloudy weather, and spring or fall turnover, also may contribute to temporary odor.

Wastewater Pond Location

A wastewater pond is best located down slope and away from the house, so the sewer line to the pond flows by gravity at the correct slope. When choosing the site, nuisance conditions, which could result from odors or accidental discharge, should be considered. Odors would least likely affect the owner when a pond is located northeast or east of the house, based on prevailing wind directions in Kansas.

Select an inconspicuous place 100 feet or more from the house and property lines, 50 feet from any surface water, 30 feet from potable water lines, out of a 100-year flood plain, and away from easements or rights-of-way. Separation distances from surface water, wells, property lines, public water lines and such must be followed from local codes or Kansas Department of Health and Environment (KDHE) Bulletin 4-2. A site plan showing all physical features — surface and buried — and contour elevations will help to locate and design a pond. The bottom of the pond should be at least four feet above highest groundwater level.

The top of the pond embankment, or berm, should be below the lowest drain or cleanout in the house. Sometimes the pond must be located upgrade of the house. This option is more expensive because a pump chamber and pump are required, and pumps are also subject to failure. When pumping is required, it is advisable to add a septic tank and have the system designed by an experienced person.

All trees should be at least 30 feet, and shrubs 15 feet, outside of the embankment. Because sunlight is essential for algae to produce oxygen, east, south and west sides of the pond should not be shaded. Vegetation no taller than a 22-degree angle (2½:1 slope) from the berm is recommended, see Figure 1. The minimum setback distance d in feet from the berm to plant trees or shrubs that reach a height of h in feet is given by the formula d = 2½× h. For example, a screen of lilac bushes will reach 12 feet tall, so they should not be planted closer than 2½ × 12 = 30 feet from the berm.

In a properly sized pond, solids are spread over a large area, so it should take at least 15 years before sludge removal is required. Tree leaves, plant debris, or wildlife in or near the pond will contribute to faster sludge accumulation.

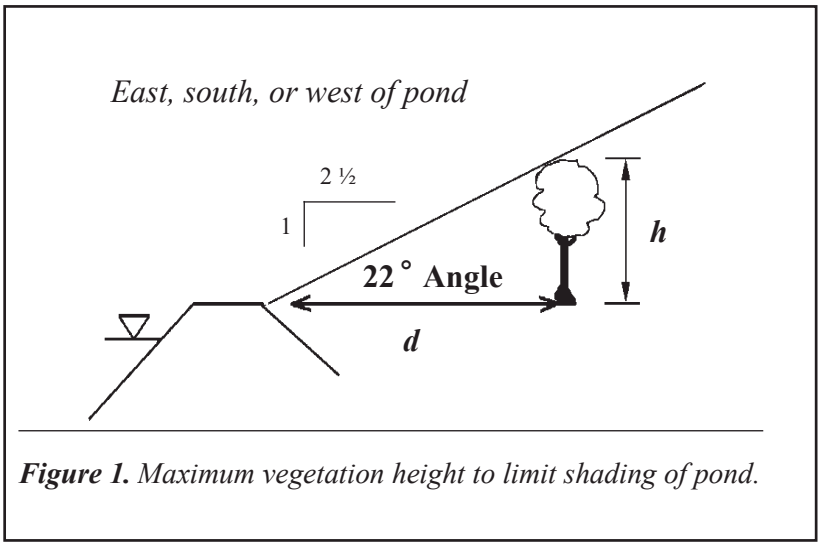

Figure 1. *Maximum vegetation height to limit shading of pond.*

Wastewater Pond Appearance

Some people don't want a wastewater pond because it is visible. Ponds need not be unsightly, nevertheless many are. A well-designed, constructed and landscaped pond can be pleasing in appearance or inconspicuous. **Maintenance of the pond and fence are essential to keep them attractive.** Hints to make a pond more attractive include the following:

- Locate the pond to blend in with existing topography and landscape. Do not place it in the center of large open meadow.
- Where possible, dig the pond into the ground (if clearance to groundwater allows), with low berms to prevent surface inflow rather than making it shallow with high berms.
- Use trees, shrubs and landscaping berm in line-of-sight or to draw attention away from the pond.
- Construct a round, oval or other shape pond rather than a square one.
- Incorporate wood or other natural material in fencing or use colored fencing so the pond is less visible.
- When a high berm is needed, locate the fence at the outside toe of the berm, so it does not add to the overall height.

Size of Wastewater Pond

Size and design of the pond involve several considerations. The water surface area must be large enough to provide adequate oxygen to keep the pond aerobic. An area of 165 square feet per person, with a minimum of 900 square feet, is usually considered adequate for oxygen transfer.

Kansas law prohibits discharge from private ponds, so they must hold all wastewater. Losses occur through leakage or seepage (maximum of ¼-inch per day), and evaporation. Maximum losses total 14 feet in Southwest Kansas, to 10 feet or less in Eastern Kansas per year.

A five-foot water depth with two feet of freeboard is ideal for easy maintenance of vegetation between the water level and top of the embankment. The minimum depth to prevent rooted aquatic growth in the pond and exposure of the inlet pipe is three feet.

Table 1 lists wastewater pond guidelines for three household sizes and three locations in Kansas. Wastewater flow must be considered, and may require a larger or smaller pond than these sizes. Experience and advice from contractors and agencies will help determine the best size. Table 1 shows the side length for square and diameter for round ponds. Other shapes may be used but length should not exceed twice the width.

	Side Length or Diameter (ft)		Area (sq ft)	Volume (1,000s gal)	
	square	*round*		*pond*[a]	*per mo*[b]
Western					
Small	35	40	1,225	18	4
Medium	40	45	1,600	26	5.5
Large	45	51	2,025	32	7
East Central					
Small	40	45	1,600	26	4
Medium	45	51	2,025	32	5
Large	50	56	2,500	43	6
Eastern					
Small	45	51	2,025	32	3
Medium	50	56	2,500	43	4
Large	55	62	3,025	56	5

Table 1. Recommended sizes of square and round wastewater ponds.

Small = 3 or fewer people; Medium = 3 to 5; Large = 6 or more

[a]Contents at 5-foot depth [b]Minimum flow to maintain 3-foot depth

Maintaining Water Balance

Sometimes additional water is required to maintain sufficient water depth and surface area. A post with depth markings (also known as a staff gauge) located near the center is recommended to monitor water depth.

One or more downspouts from the roof can be added to the pond. These connections should be easily diverted because periods of excess rainfall may add too much water to the pond. Subsurface drains and sump pumps should not be connected to the system unless a way is provided to easily divert this water from the pond during wet periods. Where a septic tank is used, excess water must be connected to the effluent line following the tank.

Sewer Line to Pond

Use at least a four-inch-diameter line from the house to the pond. All joints must be water tight as leaks attract tree roots that will clog the line, causing a sewer backup. Schedule 40 thermoplastic sewer pipe with solvent welded joints is durable, easy to lay and recommended.

Ideal line slope is two percent or two feet per 100 feet (one-quarter-inch per foot). Vary from this slope as little as terrain permits. A minimum of one foot and a maximum of three feet per 100 feet (⅛- to ⅜-inch per foot) are recommended to avoid solids accumulation in the pipe. Care in laying the line results in less maintenance and fewer problems.

At least two cleanouts should be installed, one just outside the house and a second near the pond where the ground surface is six inches above the berm (see Figure 2) for access to unplug the line. A cleanout at each change in direction and every 100 feet is also recommended. Cleanouts may be a “T” or “Y” the same size as the sewer line, but cleaning is easier if access in each direction is possible.

The line must enter the pond below the water surface to prevent freezing and ice problems, be above the bottom at least 20 inches, and should extend to near the center of the pond. The end of the pipe should be anchored by posts, steel support, or concrete blocks attached to a concrete slab (splash pad) at least two feet × two feet × four inches thick to help prevent damage to the discharge line.

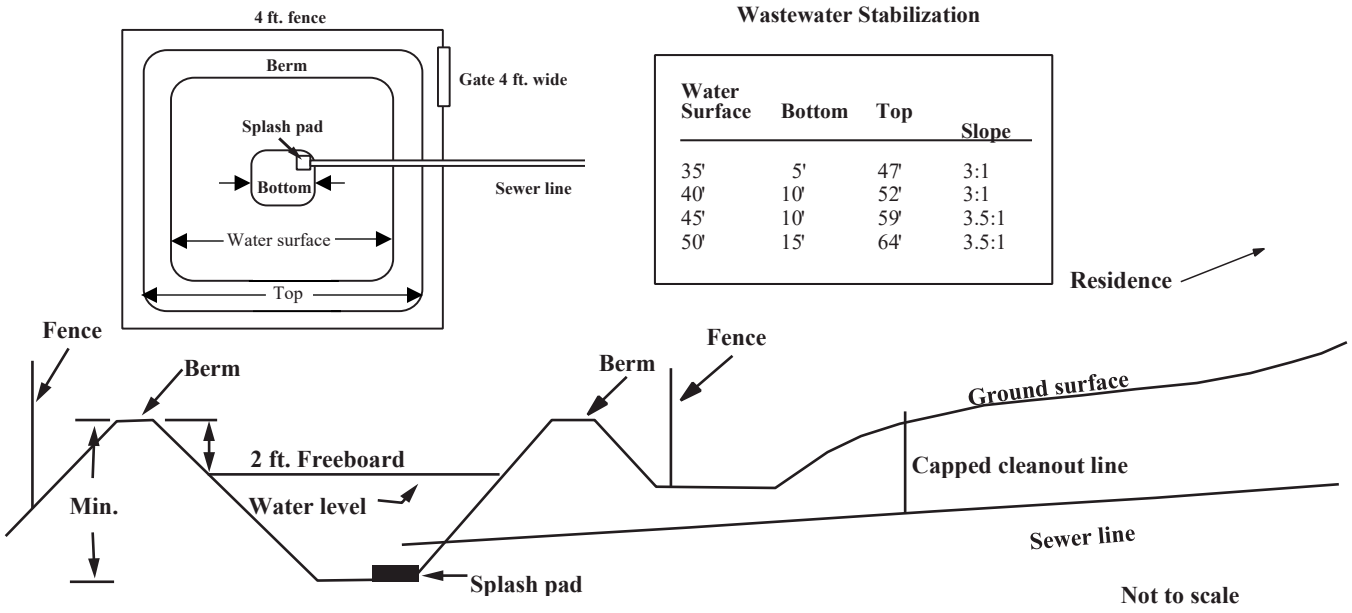

Figure 2. *Wastewater lagoon plan, dimensions and cross-section*

Permits

In counties with sanitary codes, a permit for on-site wastewater systems is required, usually through the local health department. In counties with no sanitary code, contact the local health department or KDHE for design and construction recommendations. When waste from other than domestic sources enters a pond, KDHE must be contacted and a state permit may be required.

Leaky Pond

Occasionally, a pond either will not hold water initially or will develop a leak. Excessive seepage (more than ¼-inch per day) can contaminate groundwater or surface water, so care in construction is essential. Materials that can be used to seal the bottom and sides of leaking ponds include bentonite clay, treatment additives for native clay or membrane lining. Recommendations for using these materials may be obtained from county extension office or the Natural Resource Conservation Service. See *Reducing Pond Water Losses*, available from K-State Research and Extension, Biological and Agricultural Engineering, 237 Seaton Hall, Manhattan, KS 66506-2917.

Wastewater Pond Fence

Drowning is the second leading cause of accidental death of children. Fencing of wastewater ponds is essential to protect children, pets and other animals. These ponds contain sewage that can easily spread disease and when unfenced, they are a health hazard and a liability. State standards and county codes require that they be fenced.

The fence should preferably be located at least three feet outside the embankment toe. Here it makes mowing the embankment easier and looks more pleasing. The fences should never be on the water side of the embankment because it makes controlling vegetation very difficult. A fence on top of the berm, although not recommended, should be at least four feet from the inside edge to make mowing the embankment and slopes easier. A large (at least four feet wide) rigid-frame, hinged gate should be provided to allow easy

access. When livestock are around the pond, the fence must be beyond the outside toe of the embankment slope to prevent erosion and damage to embankment. The fence should be at least four feet tall but may need to be taller.

Fence openings should be no larger than about eight square inches (2 × 4 or 2¾ x 2¾ inches) or vertical slots no wider than 1 1/2 inches. The material should be strong enough to stand up to children, wildlife and livestock if present. Kind and size of animals must be considered in selecting fence material.

A wood fence can completely hide the wastewater pond from view except from above but should not extend more than two feet above the top of the embankment. Corners with two 45-degree bends, eight to 12 feet apart, can be attractive. One barbed-wire strand must be placed at the bottom edge of the fence to discourage animals from going under. One barbed-wire strand should top the fence, but when livestock are present, use at least two strands on top.

Use of a Septic Tank

Sometimes a septic tank should be installed ahead of a wastewater pond. There are both advantages and disadvantages for using the tank, so there is no single recommendation. Advantages include reduced organic strength by 40 percent; reduced solids load, which allows use of a small diameter effluent line and an effluent pump, increased distance between cleanouts, greater variability in sewer grade and greater flexibility for placement; reduced likelihood of odors; and reduced sludge accumulation in pond. Disadvantages include increased construction cost, anaerobic wastewater discharge to pond and added maintenance for the tank.

Situations where a tank may be a benefit include when a pond must be at a higher elevation than the residence, requiring pumping; the sewer line grade must be outside the one to three percent slope range; or the needed minimal maintenance of the pond is unlikely. When a tank is used, it must be pumped regularly to avoid solids carryover that could block the effluent line.

Large House with Few People

The most difficult problem for wastewater pond sizing is a large house (several bedrooms) with only a few occupants. Design practice for individual wastewater systems is based on two people per bedroom and assumes flows of 75 gallons per person (150 gallons per bedroom) per day. Excess unused capacity is no problem for a conventional soil absorption system. However, low flow into a pond causes shallow depth, rooted vegetation, habitat for vectors that can transmit disease, poor operation and often odor. Options that help remedy these problems include the following:

1. Use a two-cell pond with the first cell sized for the minimum number of occupants and the two cells together for the full size of the home. Use an overflow pipe that maintains at least three feet of water in the first cell before overflow to the second cell. Ideally, water should rise to at least four and one-half feet deep and then be drawn down to no less than three feet. This balances water in the two cells. Both cells must be fenced.
2. Size a cell for the minimum number of occupants with an overflow pipe at the five-foot depth. Construct a second shallow (maximum three feet deep) wetland cell to receive the overflow. Select plants that do not have seed easily transported by wind or birds. Fence both cells.
3. Size the pond for the number of bedrooms but dig the bottom deeper so the bottom is the same size as a pond for only a few people.

Constructing Wastewater Pond System

A small bulldozer or front loader is ideal for building a pond. Make side slopes no steeper than 3:1, provide a freeboard of at least two feet above the normal depth and a minimum berm top width of five feet. Divert surface water from the pond with the embankment or a diversion on the up-slope side. Finish the berm to a uniform surface above the water line for ease in mowing. Figure 3 shows a well-constructed pond with good fencing.

Many soils have a topsoil layer that is more permeable than the high clay subsoil. When constructing a pond, the permeable (topsoil) layer must be stripped from the surface and embankment base before excavating the bottom and forming the embankments. Compact undisturbed sides in place. Embankment fill should be compacted in layers no more than six inches thick. When rock is encountered in excavation, the hole must be over-excavated by at least one foot to remove rock, then fill and compact at least one foot of clay material.

Compaction has a wide range of meanings depending on viewpoint. A minimum is to consolidate and fill large openings by running over the fill with construction machinery. The best method is to compact moist six-inch fill layers, sides and bottom with a sheep's foot roller until it walks out (compacts enough that spikes no longer penetrate).

Moisture content has more effect on compaction than type of machinery used. When the soil is muddy, it is too wet to compact well. The best condition is when the soil is moist enough to easily work into a ball. The more the soil is manipulated at this moisture condition, the more voids will be worked out of it and the less permeable it will be. Careful compaction is important for soil that is borderline for wastewater ponds.

Finally after the embankment berms are complete, replace the topsoil over the outside, top and upper few feet of the inside of the embankment. Seed the embankment to perennial grass, and apply and anchor a straw cover or erosion blanket for soil protection.

The sewer line trench bottom should be undisturbed soil and free of rocks that could break the line. Backfill and compact around the sides and over the pipe until two inches of fill cover the pipe. Compact the remainder of the trench fill in six-inch layers. Finally mound over the trench about six inches to allow for settling of the trench fill.

Figure 3. *A well-constructed new wastewater pond — this chain-link fence will have a long life and requires little maintenance.*