Chapter IX

WASTEWATER POND (LAGOON)

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INTRODUCTION

A septic tank followed by an in-ground soil absorption system is the preferred on-site wastewater treatment system when site and soil conditions are suitable. However, when the soil is too impermeable for an in-ground system and adequate area exists, a lagoon may be an option. Soils with high clay; poor drainage; seasonal perched water table; or platy, very weak, or massive structure are typically poorly suited to soil absorption but often well suited to lagoons.

A properly designed, constructed, and maintained lagoon will treat wastewater, protect human health and the environment, and can be inconspicuous. It is important to remember, however, that a wastewater lagoon treats raw sewage. Raw sewage is a health hazard. The lagoon must be properly maintained in order to function as it should, and protect human health and fresh waters of the state. This chapter addresses all aspects of construction, operation, and maintenance of a lagoon. It should be diligently followed.

Proliferation of single-family wastewater lagoons within subdivisions of many homes should be avoided when other options are available. Multiple lots in close proximity with soil poorly suited to traditional in-ground systems may be suitable to other wastewater treatment options. A cluster system consisting of collection, pretreatment, and soil dispersal on a dedicated site should be considered as discussed in Assessing Wastewater Options for Small Communities in Kansas Manual (1999). This manual is available on the Kansas Department of Health and Environment (KDHE) website.

This chapter of the Environmental Health Handbook has been prepared to provide guidelines for the design, construction, operation, maintenance, and repair of small (less than 2,500 gallons per day) nondischarging wastewater lagoons. Guidelines in this chapter are intended primarily for private wastewater facilities for individual homes. However, guidance for wastewater treatment lagoons may be adapted to serve schools; institutions; and businesses such as motels, restaurants, camps, and mobile-home parks that have domestic type wastewater.

Any system receiving industrial wastewater, including shop floor drains, must be referred to the Kansas Department of Health and Environment.

HOW TREATMENT OCCURS IN A WASTEWATER LAGOON

Lagoons support physical, biological, and chemical processes that result in treatment of wastewater. Natural conditions in a properly operating lagoon result in three layers: aerobic on top, anaerobic on the bottom, and an intermediate or mixed layer. Treatment and conditions are different in each of the three layers. Wind on the surface of the lagoon is important to introduce oxygen into the water, supporting aerobic bacteria in the top layer. Sunlight supports algae growth in this layer. Algae produce oxygen through photosynthesis, supporting the aerobic bacteria. The bacteria release carbon dioxide used by the algae. To assure wind and sun exposure to the lagoon, trees and shrubs must be sufficiently distant so as not to shade the lagoon or inhibit wind contact.

When functioning stably, this symbiotic relationship results in a bright green color at certain times of the year. When wastes are broken down, some gases are released into the air and small amounts of solids settle to the bottom. In a properly constructed and managed lagoon, household wastewater can be treated for up to 30 years and solids will not likely build up to the point they

need to be removed. It is essential to maintain the lagoon in a properly functioning state. The Protocol – Home Maintenance and Inspection Checklist at the end of this chapter summarizes ongoing, required maintenance.

KDHE AND LOCAL JURISDICTION RESPONSIBILITIES

The Kansas Department of Health and Environment has defined their responsibility for permitting wastewater lagoon systems as follows:

1) Discharge to the surface.

2) Receive any amount of industrial wastewater discharge.

3) Serve wastewater systems owned by local government or other public entity.

Authority to regulate wastewater lagoons is granted to local governments under K.S.A. 19- 3701 et seq., K.S.A. 19-101a, K.S.A. 12-3302 or 3303, and K.A.R. 28-5-6.

Local governments may regulate wastewater treatment lagoons if they have a KDHE-approved sanitary code, providing them authority. The lagoon must be nondischarging and receive less than 2,500 gallons per day of domestic sewage. For more detail, see Protocol – Permitting Authority at the back of this chapter.

CONSIDERATIONS FOR LAGOON SITING

Due to space requirements and access for maintenance and repair, many factors must be considered in deciding on a lagoon for sewage treatment. These factors include the following:

1) Adequate space – the footprint area required by a lagoon may be 10,000 square feet or more, for an individual home, and potentially larger for a business. In additional to the initial lagoon location, planning for a replacement must also be considered.

2) Separation and setback – distances from property lines, wells, surface water and drainage, easements, buildings, and flood plain are determined by local code and state minimum standards. See Table IV-7 in Chapter IV for minimum required and recommended setback. All buried gas, electrical, or other utility lines must be located prior to excavation.

3) Separation of tall vegetation – the site should have adequate separation distances from trees and other vegetation that could impair functioning, especially shading, air-flow restriction, and leaf drop.

4) Ease of maintenance – routine care of berms, fences, and vegetation is required on a regular schedule.

5) Site conditions – slope of land and restrictive soil conditions within 5 feet of the ground surface. A high-water table or a saturated zone near ground surface may prohibit a lagoon.

6) Adequate area – a minimum lot size of 3 to 5 acres is typically needed to accommodate a private well and lagoon with all required setback and/or appropriate separation distances.

7) For more specific information, see Protocol – Evaluating and Siting a Lagoon later in this chapter.

SITE EVALUATION

See Chapter IV of this handbook for additional discussion about site and soil evaluation. Conducting a proper site evaluation for a lagoon includes the following specific steps:

1) Determine the appropriate local agency responsible for facility permitting. In most cases this would be the sanitarian in the local health department, or planning and zoning office.

2) Conduct a preliminary site evaluation to select the most suitable location. See Protocol Site Evaluation for On-site Wastewater Systems in Chapter IV. Note all conditions that could adversely affect location and construction, such as private or public water wells or pipelines, sandy or rocky soil, utilities, easements, property lines, topography, and geology. Utilize all available site-specific information such as site history, soil profiles, and county soil survey book available from the local USDA NRCS office or the NRCS Web Soil Survey.

3) Evaluate potential effects of unexpected overflow or release, and resultant contamination to surrounding property and environment.

4) Based on a soil profile evaluation, obtain the estimated design loading rate (DLR) using Table IV-4 in Chapter IV. Soil textures and structures with no suitable DLR are frequently acceptable for a wastewater lagoon with adequate compaction. Fine-textured soils with a DLR of 0.2 gallons per day, especially in Eastern Kansas, may be suitable for lagoons.

5) Compare results with permeability of the soil on the site in the SCS/NRCS county soil survey to see if general agreement exists. Large discrepancies in results should be reconciled by further testing, done by someone experienced with soil texture, structure, and permeability.

A lagoon location downslope and downwind from the source is preferred so sewage will flow by gravity at the correct slope. The site should be downwind of the residence or facility to minimize possible nuisance conditions such as odor, in Kansas usually to the east or northeast. Only rarely do objectionable odors occur from a properly operated and maintained lagoon. However, odors may be noticed for a brief period in the spring or fall when a stratified lagoon turns over or when there are several consecutive overcast days.

Separation distances from surface water, wells, property lines, and public water lines must be in compliance with local codes and/or KDHE Bulletin 4-2; or Chapter IV, Table IV-7 in this handbook.

A detailed site plan showing all physical features, surface and buried, and contour elevations will be a great help to locate and design a wastewater lagoon. The bottom of the lagoon should be at least 4 feet above the highest groundwater level or other limiting conditions.

To assure adequate drainage and to avoid the risk of a backup in the residence or facility, the top of a lagoon berm should be below the lowest drain or cleanout in the house.

Sometimes the lagoon must be located upgrade from the house, which necessitates a pump tank and pump. Pumps are subject to failure, require an energy source and maintenance, and will increase costs. When pumping is required, it is advisable to add a septic tank and use an effluent pump. To assure good hydraulic operation, use a high-quality sewage or grinder pump and have the system designed by an experienced person. Adherence to hydraulic principals including pump selection and backflow prevention from the lagoon are essential.

The findings of site investigation and pertinent preliminary information should be reviewed with both parties. An original, and at least two additional sets of construction plans and specifications should be prepared. The contractor and homeowner should receive the copies and the original should be retained in the office permit files.

Applicants need to be informed that single-family wastewater lagoons are to be constructed, operated, and maintained according to county or city/county requirements. Failure to do so can result in a declaration of a public health nuisance by the local board of health (KSA 65-159) and prosecution by the county attorney (KSA 65-160).

Additionally, applicants should be informed that if a central collection system becomes available, within 400 feet of the property, connection to the central collection system may be required as defined by county code. If connection occurs, proper abandonment of the wastewater lagoon must occur.

When the site evaluation indicates a lagoon is the most appropriate and acceptable option, sizing, design, specifications, and construction plans are the next step.

SIZING THE LAGOON

The primary objective of sizing the lagoon is to provide adequate depth and wastewater treatment, and prevent overflow. Optimum lagoon water depth is 5 feet measured from the bottom of the lagoon to the water surface. Satisfactory operation occurs with water depths of 3 to 5 feet. Water level may drop as low as 2½ feet for short periods without adversely affecting the lagoon's operation. However, sunlight may penetrate a shallower depth and plant growth across the lagoon bottom with depths less than 2½ feet will impair a lagoon's operation.

Estimating wastewater retention in a lagoon is achieved by identifying the amount of wastewater flow minus net water loss. Water loss occurs through evaporation and seepage. Evaporation plus seepage can range up to 14 feet in annual loss in Southwestern Kansas, to 10 feet or less in Eastern Kansas. Seepage varies with the soil and compaction from very low to the maximum allowable of 0.25 inches per day (few inches to 7.6 feet per year). Preferably, seepage should be no more than 1/8-inch per day. Precipitation and evaporation data are collected only at certain sites across the state and have been extrapolated to include areas where data were not available.

Wastewater flow for sizing a lagoon is based on average flow rather than peak flow, which is used for sizing an in-ground wastewater system. Lagoons easily handle temporary high flows with a rise in water level, which results in an increase in losses. Conversely, in-ground systems must be able to handle these peak flows to avoid malfunction or failure.

Actual water records, when available, are a preferable source of determining expected average flow. Factors to consider when estimating wastewater flow to size of lagoon follow:

1) Wastewater design flows are based on average number of persons expected to reside in the house. This is certainly less than full occupancy of two persons per number of bedrooms. Use a wastewater flow rate of typically 40 to 50 gallons per person per day. Use two- to five-person average occupancy for a three-bedroom house with corresponding flows of 100 to 250 gpd.

2) Assess lifestyle factors for a deviation above or below the average wastewater flow. Low wastewater flow may result in lower average water depths, which allow rooted vegetation, rodent and disease-transmitting insect habitats, poor operation, and excessive odor. For example, a couple living in a four-bedroom home might better utilize a lagoon dug deeper to a smaller base, requiring less water to maintain adequate depth. The deep part of the lagoon would be sized for a home with two occupants. The overall size would be adequate for eight occupants. Alternately, a two-cell pond could be used to achieve maximum-capacity sizing. The first cell is sized for the minimum number of occupants; both cells together would accommodate the full size of the home. An overflow pipe between the two cells that maintained 3 feet of water in the first cell before overflowing into the second cell could be used. Ideally water in the first cell should rise to 5 feet deep and be drawn down to no less than 3 feet deep. Both cells must be fenced and maintained to keep weeds from growing or rodents from burrowing and damaging the liner. Once a second cell is used, it is important to maintain the 3-5-foot depth in both cells. A third option is to use a cell sized for the minimum number of occupants, with an overflow pipe at 5 feet. The overflow runs to a second, shallow (maximum three feet deep) wetland cell. Select plants that do not have seed easily transported by wind or birds. Fence both cells.

3) Additional water may need to be added, especially during dry periods. Ways to do this are from roof guttering and downspouts, sump pump that includes or diverts drainage, or the household water supply, especially from a private well. Construct all such diversions so they are easily disconnected during periods of excess rainfall because they may add too much water to the pond.

4) Avoid discharging large doses of chemicals to a lagoon to protect its chemical balance. Large doses of disinfectants from water well disinfection, swimming pools, or hot tubs, among other chemicals, can upset the lagoon's biological balance.

Table IX-1 lists guidelines for three household sizes and three locations in Kansas. Experience and advice from agencies and contractors will help determine the most suitable size. Table IX-1 shows the side length for square lagoons and diameter for round lagoons. Other shapes may be used but length should not exceed twice the width.

Table IX-1. Recommended sizes for square and round wastewater lagoons

	Square-side length ft[a]	Round diameter ft[a]	Surface area square ft[a]	Volume 100s gal[a]	Minimum flow per month[b]
Western					
Small	35	40	1225	18	4
Medium	40	45	1600	26	5.5
Large	45	51	2025	32	7
East Central					
Small	40	45	1600	26	4
Medium	45	51	2025	31	5
Large	50	56	2500	43	6
Eastern					
Small	45	51	2025	32	3
Medium	50	56	2500	43	4
Large	55	62	3025	56	5

These sizings are based on an assumed 1/4-in/day seepage loss
Small = 3 or less people; medium = 3-5 people; large = 6 or more;
[a] contents at 5-ft depth;
[b] minimum flow (1,000 gallons/month) to maintain a 3-ft depth

All city and county code requirements shall be met prior to construction. Construction of a wastewater lagoon may be considered if soil properties at the bottom of the lagoon are satisfactory as indicated by slow percolation rates, minimal porosity, and fine soil texture. Soil profiles can be used to determine texture giving percentages of sand, silt, and clay. A soil profile evaluation is recommended because permeability rates obtained from a perc test vary in accuracy depending on soil moisture content at the time of testing. In the absence of a soil profile evaluation, a permeability rate of less than an inch per hour indicated by a perc test may be a good indicator for a suitable lagoon site.

Separation distance requirements: *These measurements are from the inside of the berm at the 5-foot operational water level as measured vertically from the bottom of the lagoon.*

1) A minimum of 50 feet (200 ft recommended) from property boundaries. Sometimes adjacent property owners are willing to agree to a legal easement in which a wastewater lagoon may be constructed closer. An adjacent property owner needs to be made aware that construction of a private water well requires a 50-foot distance from a wastewater lagoon. If a legal easement is obtained, a wastewater lagoon may be constructed closer than 50 feet from adjacent property. Legal easements must be filed with the register of deeds to protect the interests of all present or future parties.

2) Public roadways (total right-of-way) may be considered part of the separation distance; however, no part of a wastewater lagoon may be placed on a public access or utility easement.

3) Any potable public water supply or suction line must be 100 feet from the lagoon's operational water level.

PRETREATMENT OPTIONS FOR LAGOONS

In most cases a lagoon will work fine with no pretreatment of normal household wastewater before it enters the lagoon. The ideal sewer grade is 1/8- to 1/4-inch of drop per foot of sewer pipe or 1 to 3 percent grade of the sewer line. Slopes substantially greater or flatter than this can lead to problems of solids separation from the wastewater.

A septic tank can be added ahead of the lagoon to remove solids and reduce problems resulting from a substantially flatter or greater grade on the line leading to the lagoon. A septic tank has the advantages of removing solids (this expands the range of suitable sewer grade slope), reducing organic load (aids lagoon function), minimizing the chance of odor as long as the discharge line is under the water surface, and reducing rate of solids accumulation.

Other advantages include allowing use of a smaller-diameter effluent line and effluent pump, increased distance between cleanouts, greater variability in sewer grade, and greater flexibility for placement. Disadvantages include increased construction cost overall, anaerobic wastewater discharge to a pond, and maintenance for the tank. When a tank is used, it must be pumped regularly to avoid solids carryover that could block the effluent line. Outflow from the septic tank is still sewage and because of bacteria and safety issues, the lagoon must still be fenced.

GUIDELINES FOR DESIGNING AND CONSTRUCTING LAGOONS

1) **Rock or porous strata**. Excavation that penetrates or terminates in rock or porous strata should be over-excavated a minimum depth of 2 feet on both side slopes and bottom. The entire excavation area must be filled with nonpermeable earthen material to limit seepage from the lagoon to a maximum value of 1/4-inch per day (0.01 inch per hour). Use high clay subsoil that is free of rocks, or fill soil that is mixed with bentonite clay and applied at the manufacturer's recommended rate and then compacted.

2) **Compact to avoid excessive water loss.** Compaction is essential to achieve consistent low water loss from lagoons. A sheepsfoot roller compacted lining built in three- to six-inch lifts to make a lining of at least 1½ feet thick is strongly recommended. See Protocol – Compacted Linings at the end of this chapter.

3) **Prevent surface water entry.** Divert surface runoff to prevent sediment entry and lagoon overfill/overflow. Construct the berm above the surrounding soil level or make an interception terrace (trench and ridge) to carry runoff away from the upslope side to accomplish this.

4) **Prevent berm erosion with vegetation.** Following final grading, establish a perennial or temporary annual groundcover on the berm as soon as feasible; mulching until vegetation is established helps prevent erosion.

5) **Assure adequate air flow and avoid shading.** Sunlight and air circulation over the lagoon are essential for good lagoon operation. Trees need to be located at least 30 feet outside the embankment and shrubs should be at least 15 feet outside the embankment. Because sunlight is essential for algae to produce oxygen, a lagoon's east, south, and west sides should not be shaded. It is recommended no plants grow taller than a 22-degree angle (approximately 2½ horizontal to 1 vertical ratio) from the top outer edge of the berm.

6) **Fence for human and animal safety.** These lagoons contain raw sewage that can easily spread disease. If unfenced, they can create both a hazard and liability, especially with drowning, which is the second leading cause of accidental death in children. State and county codes require all wastewater lagoons be fenced. Fencing should preferably be located 3 feet outside the berm toe. A 4-foot-wide, rigid-frame hinged gate can allow easy access to mowing equipment. Gating must provide the same degree of resistance to entry as fencing and requires a padlock. Fencing diagrams are located in Figures IX-1, IX-2, IX-3, IX-4, and IX-5.

Specifications for lagoon fence

a) Height: 4 feet minimum. If fence will also be accessible to livestock, a double strand of barbed wire placed above the fence top or an electrical fence placed outside the inner fence may also be installed.

b) Size: 12.5-gauge wire.

c) Open space: 8 square inches or smaller; example 2" x 4."

d) Warning signs: A sign stating "WASTEWATER TREATMENT LAGOON" or "RAW SEWAGE, KEEP OUT," shall be posted on the gate or fence adjacent to the gate.

CONSTRUCTION

1) **Soil condition**. Soil moist enough to compact into a firm ball is most suitable. Muddy soil is not only difficult to work but also forms clods that can be difficult to smooth out. Soil too dry for compaction into a firm ball can have moisture added.

   Topsoil needs to be removed and stockpiled for later use on the berm. Once the lagoon construction is completed, the topsoil may then be placed on the berm surface to support groundcover growth. Berm compaction needs to be done in layers, preferably by sheepsfoot roller, rather than by machine traffic or other provision. This practice is critical if the soil is borderline acceptable for a wastewater lagoon. Fill layers shall be no more than 6 inches thick.

2) **Lagoon depth**. Lagoons are normally excavated to a depth no greater than 8 feet below the surface of the surrounding ground. Greater depth may contribute to problems of inadequate sunlight and/or air transfer. Surfaces of the berm and lagoon bottom should have uniform slope. They need to be free of rocks, debris, ruts, and ridges. When rock is encountered in excavation, the hole must be over-excavated by at least one foot to

remove rock, then filled and compacted with at least one foot of clay material. The bottom of the lagoon must be at least four feet above the highest expected groundwater level or fractured bedrock.

3) **Berms.** Wastewater lagoons must be completely enclosed by berms 3 feet higher than the surface of the surrounding ground. Both the interior and exterior slope should be no less than 3 feet of lateral movement for each foot of vertical drop; 3.5 ft is better when space allows. The top width of the berm should be at least five feet to allow for easier mowing.

4) **Linings.** Where soil percolation rates exceed one-inch fall per hour, the bottom and interior sides of the wastewater lagoon need to be lined with a compacted clay of sufficient thickness to reduce the soil absorption rate to 1/4-inch per day or less, preferably 1/8-inch per day. See Protocol - Compacted Lining at the end of this chapter. Refer to manufacturer's recommended rate when using bentonite clay, asphalt cement, or membrane application.

5) **Sewage inflow.** The pipe carrying wastewater from the house to the lagoon must be at least 4 inches in diameter. Schedule 40 thermoplastic sewer pipe with solvent-welded joints is recommended. Slope can vary between 1/8- and 3/8-inch per foot. A 1/4-inch slope per foot, or 2-foot slope per 100 feet is recommended to avoid solids accumulation in the line. Pipe entry needs to be located below the water surface and extend nearly to the lagoon center, ideally located at 18 to 20 inches off the bottom. Beneath the pipe ending, at the lagoon center bottom, place a concrete pad of 2 feet x 2 feet x 4 inches thick. This pad can protect the lagoon lining from effluent damage. Supporting the end pipe can be done by anchoring it above concrete blocks with posts and/or steel support.

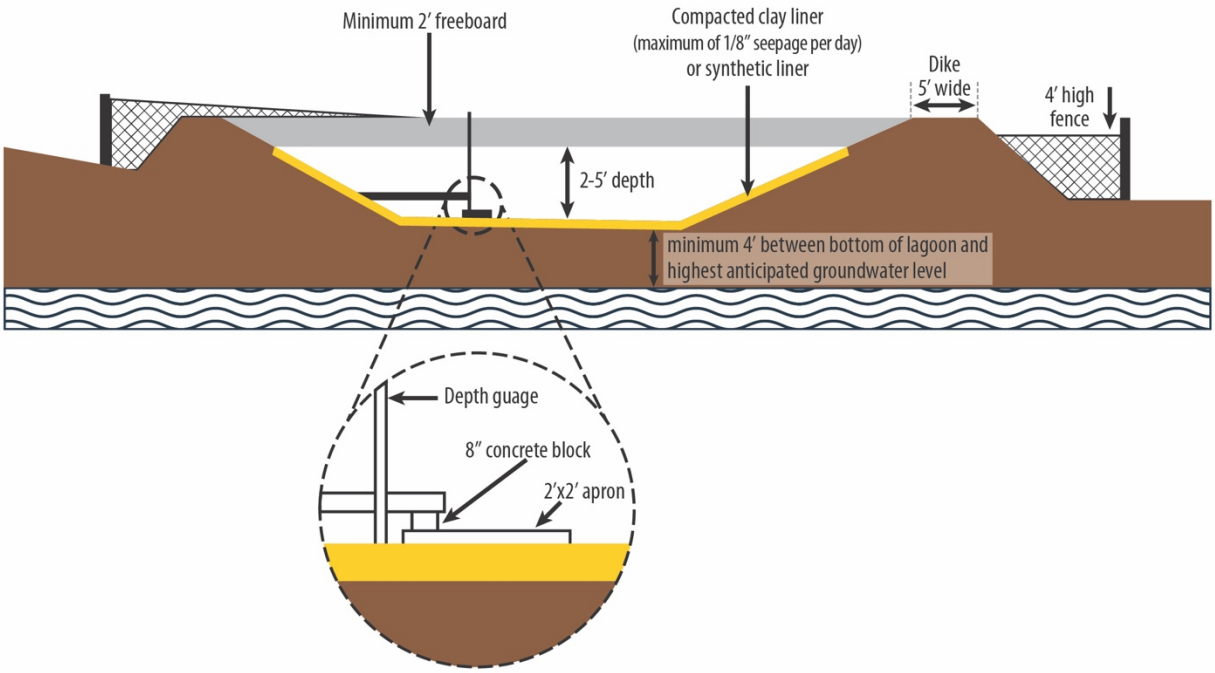
6) **Monitoring lagoon-water depth.** Installation of a post with clear markings in one-foot increments, located near the center, is recommended for ease in observation of water depth. Bentonite or clay soil can be packed around the base of the marker.

7) **Install at least two cleanouts.** One located near the outside of the house and the second one near the lagoon where the ground surface is approximately 6 inches higher than the berm, are favorable locations. Additional cleanouts are recommended with any change in pipe direction or distance of greater than 100 feet. A Tee or Y design may be used. However, a Y- shaped design allows easier access and double cleanouts allow for easier cleaning in both directions.

8) **Topsoil replacement to berm.** Application of topsoil is for the purpose of supporting groundcover growth. Reapplying topsoil by spreading in a loose manner is desirable, or if packed too firmly, it can be tilled prior to planting groundcover. Perennial groundcover, for preventing erosion, needs to be seeded as promptly as possible following construction. Natural Resources Conservation Service or Extension may provide recommendations for groundcover most suitable to one's specific location. Protective covering of straw or hay mulch may be beneficial in holding the soil and seeding during the process of establishing groundcover growth.

9) **Fencing installation.** Fencing must be completed as soon as possible for public safety. Posts need to be placed 2½ to 3 feet deep and backfilled with tightly compacted soil. Placing cemented posts at a 2½-foot depth is an alternative option. Wire needs to be stretched tightly using a come-along (wire stretcher), tractor, or other method. Figures IX-1 through IX-5 illustrate gate and fencing specifications.

Figure IX-1. Lagoon Design



TESTING FINAL SEEPAGE RATE

Use one of three ways to test the final seepage rate of the lagoon to assure it does not exceed ¼-inch per day. A rate of 1/8-inch per day is preferred. An independent soil lab can take a sample of the soil for testing prior to filling the lagoon. This may be expensive and leave a hole that would compromise the lagoon. The hole can be plugged with bentonite or soil used for the liner, and then compacted.

Alternately, the two-barrel method requires two 55-gallon drums. One is the "control" drum, which records water loss due to evaporation or gain due to precipitation. This drum is set on the bottom of the lagoon, closed end down. The second drum has had the top and bottom removed. This is the "seepage" drum. It is placed a few inches into the sealed soil layer on the bottom of the lagoon. A bead of bentonite should be packed around the inside edge of the drum. The seepage drum should be kept filled with water for two days prior to beginning the test. This assures the soil is saturated. Weights are suspended on the outside of the seepage drum to keep it from popping up during the test; however, the top must remain uncovered so there is no interference with precipitation entering the drum. To conduct the test, fill each drum with an

equal amount of water. For at least seven days, measure and record the difference in water levels; refill the barrels to the original levels. The difference between the two levels in the barrels is due to seepage and must not exceed ¼-inch per day. A 1/8-inch seepage rate is preferable.

Another choice for testing seepage is the five-gallon bucket test. To conduct this test, fill the lagoon with fresh water to a depth of two feet. After water sits for two days to achieve soil saturation, mark this level on the permanent depth marker. Near the lagoon, partially bury a five-gallon bucket filled with water to a line marked near the top. Water-level changes in the bucket will be due to weather. The changes in the lagoon will be the result of weather and seepage. Record the water levels daily for at least seven days. The difference in the measurements is the seepage. It must not exceed ¼-inch per day and 1/8-inch is preferred.

If seepage exceeds ¼-inch per day, bentonite or soda ash must be added and compacted on the lagoon bottom and sides, or a synthetic liner must be installed.

INSPECTION

Sample inspection report forms are provided at the end of this chapter. These may serve as a guideline in addressing important points of an inspection.

OPERATION AND MAINTENANCE

1) **Establish and maintain groundcover.** All areas bounded by the toe of the berms and within the fence shall have an ample stand of low-growing perennial groundcover. Once the groundcover is established, it needs to be regularly maintained during the growing season at a height of 6 inches or less. Under no circumstances should trees or tall weeds be allowed to develop on the berm area. Near the lagoon edge, it is preferable to cut the vegetation shorter than 6 inches to prevent any drooping into the water. Ideally, grass clippings should be removed from the lagoon area. At a minimum, they must be directed away from the lagoon.

2) **Remove any trees and additional vegetation.** All trees, weeds, cattails, duckweed, floating algae, and other undesirable vegetation need to be removed promptly with the first signs of their development in the water or along the berm. This vegetation is a habitat for mosquito breeding, produces excess organic loading, and degrades oxygen transfer. The best way to keep these plants from growing in the lagoon is to keep three feet or more of water in it. Removing weeds by hand before they become embedded and contribute to the lagoon's organic load is advisable. Take precautions to minimize exposure to wastewater by wearing protective clothing and waterproof gloves. After working with wastewater, thoroughly wash hands, or shower and disinfect any breaks in skin. Excess vegetation can create additional problems including a reduction of air flow, decreased evaporation, lagoon filling, shading, and less sunlight activity over the lagoon. Mosquito production is often directly proportional to the amount of such vegetation. Destruction of the lagoon's seal by root penetration can also occur. To repair a leaking lagoon, see Protocol – Sealing a Leaking Lagoon at the end of this chapter.

3) **Avoid herbicide use. Improper use of herbicides can cause temporary system failure.** If use becomes necessary, consult with the local county Extension Office or environmental health officer for the most recent product advice. Follow the

manufacturer's label, and avoid spillage or drift that might cause chemical holes or kill groundcover on the berm.

4) **Keep undesirable materials out of the wastewater.** It is important to keep hazardous materials (drain cleaners, paint, varnishes, solvents, fuels, waste oil, photographic solutions, pesticides or other organic chemicals) out of domestic wastewater that enters the lagoon. Also, minimize fats and greases that may clog the pipes as well as feminine hygiene products, coffee grounds, bones, cigarette butts, disposable diapers, paper towels, facial tissues, and other materials that decompose very slowly.

5) **Maintain desirable water depth – as close as feasible to 5 feet.** A short-term water depth of 2.5 feet during drought conditions is acceptable. Adequate treatment can become a problem if the depth becomes less than 2.5 feet. Therefore, a design of directing roof drains and/or sump pump wastewater to the lagoon as a temporary condition is desirable and must include a plan for rerouting the same wastewater elsewhere during prolonged periods of wet weather. Two feet of freeboard (berm height above the water surface) for water storage needs to be maintained to provide for times of exceptional storms. For emergency situations in which wastewater is encroaching on the freeboard and may overflow the lagoon, follow procedures in Protocol - Emergency Dewatering at the end of this chapter.

6) **Repair berm damage.** A certain amount of erosion will occur on the berm after initial construction. Any damage incurred by reasons of weather, animal entry, or other means should be repaired by shaping the area to the original plan and reestablishing perennial groundcover. Among the most common causes of damage are settling, erosion, and rodent burrowing.

7) **Evaluate wastewater lagoon conditions.** Proper operation of a wastewater lagoon can be evaluated by color, odor, and water testing. Generally routine testing is beyond the ability of the owner or user. Thus, one must rely on appearance and odor for operation information. Table IX-2 gives a color-interpretation guide. Lagoon color is directly related to pH and dissolved oxygen (DO).

8) **Maintain essential lagoon features.** The fence, gate, vegetation height, and inlet pipe shall also be maintained in the condition called for in the original plans and specifications. Assure the fence and gate are in good condition at least twice per year. The gap between the gate and post or space at the bottom of the fence to the ground should not be bigger than 2 inches. Check for loose or damaged posts, loose anchors, sags in wire, and any damage. The fence must keep animals, especially pets, and children away from the lagoon. Any diversions provided to keep surface runoff away shall be maintained in satisfactory condition and at sufficient height to protect the lagoon.

9) **Pay attention to odors.** Properly operating lagoons rarely emit an odor. Odors may indicate the lagoon is not functioning properly. Odors may be due to the following: a) sludge may be filling the lagoon; b) lagoon may be improperly sized; or c) lagoon may be overloaded. Odor that persists longer than two days indicates an operational problem and the cause must be determined.

10) **Measure and record sludge.** Maintain at least 18 inches of water above the level of sludge. Measure the depth of sludge in the same area of the lagoon, preferably near the center, after 10 years, and then again every three to five years. It is not safe to walk into a lagoon with waders. Rather, use a small pump with an intake suspended from a float at an adjustable depth. Move the intake deeper until solids are first noticed. The depth of the intake below the surface is the depth to the sludge. Keep a record of depths of sludge and the years it was measured.

Table IX-2. Visual Indicators of a Lagoon's Condition

COLOR	CONDITION	SYMPTOM OR CAUSE
Dark sparkling green	good	high pH and DO
Dull green to yellow	not as good	pH and DO are dropping blue-green-type algae are becoming predominant
Gray to black	very bad	lagoon is septic with anaerobic conditions prevailing
Tan to brown	Ok if…	due to predominance of a type of brown algae (not found in Kansas)
	Not good if…	due to silt or bank erosion

Source: Stabilization Ponds - Operations Manual. Aug 1977, EPA Office of Water Program Operations, O-15

SLUDGE REMOVAL

Wastewater lagoons will begin to fill with silt, sludge, and organic debris after a period of extended use. Lack of maintenance will increase the rate of fill. Leaves, uncut grass, grass clippings, waterfowl, animal burrowing, and livestock damage will accelerate the rate of filling occurring in the lagoon. Original lagoon volume must be maintained so that overflow does not occur.

Evidence of filling includes 1) overflow; 2) presence of cattails or other aquatic vegetation toward the center of the lagoon; 3) over-loaded condition indicated by heavy algae growth, dark lagoon water, decreased wave action, slow-flowing toilets, and foul air odor; and 4) water level on the berm near overflow condition during periods of normal rainfall.

Any of the above conditions, by themselves, may be attributed to inadequate lagoon sizing, or unusually heavy or light wastewater flow. Dewatering may be necessary to determine the cause. Consulting the local environmental health officer for assistance in determining whether to clean and reconstruct, abandon, or initiate other corrective action may be beneficial.

Procedure to clean and reconstruct the lagoon:

1) Contact the regulating authority for permit requirements or improvement requirements.

2) Lagoon dewatering must be accomplished with the greatest degree of environmental safety possible. Refer to Protocol - Emergency Dewatering Procedure at the end of this chapter.

3) Sludge may then be removed, utilizing a backhoe, bulldozer, or front-end loader in accordance with guidelines established by the local regulatory agency. The sludge can then be taken to a publicly owned wastewater treatment facility such as a landfill permitted and willing to accept sludge, or it can be tilled into farmland. If the sludge material is applied to farmland, it needs to be tilled into the soil as soon as possible (within 24 hours). (Refer to EPA 40 CFR Part 503 Regulations.)

4) Clay or bentonite layers, or lining originally installed to control seepage losses need to be checked and restored. See Protocol - Sealing a Leaking Lagoon at the end of this chapter.

5) Inlet pipes and cleanouts need to be checked for proper functioning with repairs made if needed.

6) Berm must be reshaped, packed, and smoothed. Reseeding and restoring the fence to an approved condition needs to be done.

7) Water level should be restored to a 2 ½-foot depth before the lagoon is returned to service.

LAGOON ABANDONMENT

Reasons for abandonment of a wastewater lagoon may include the following:

1) Public sewer available to the property within a feasible distance.

2) Lagoon will not retain wastewater.

3) Sludge level is at a depth that impairs proper functioning of the lagoon.

4) Local environmental health officer determines the system cannot be made to function properly; cannot adequately protect health of property owner or health of the public, or the quality of state waters.

Abandoning a wastewater lagoon would normally entail dewatering, sludge removal by a licensed septage hauler, and returning the land area to the contour it held prior to lagoon construction. Kansas Department of Health and Environment issues addendums as new laws and procedures are developed. Wastewater lagoons are subject to these additions. Current guideline procedures for abandoning a wastewater lagoon are as follow:

1) Dewater according to the Protocol – Emergency Dewatering procedure at the end of this chapter.

2) If the dry sludge is more than 18 inches thick, it should be removed and disposed following the local code and EPA 40 CFR Part 503 regulations, then proceed with the steps below.

3) Push berms in to fill lagoon. A slight elevation above the center is desirable to eliminate the possibility of an area holding water once settling occurs.

4) Cover the area with topsoil and reseed with suitable groundcover.

REFERENCES AND OTHER READING MATERIALS

The following publications are available from K-State Research and Extension, https://bookstore.ksre.ksu.edu/ or local Extension office.

Aquatic Plants and Their Control, C-667, KSU Agricultural Experiment Station and Cooperative Extension Service, https://bookstore.ksre.ksu.edu/pubs/c667.pdf, August 2005.

Site and Soil Evaluation for Onsite Wastewater Systems, MF-2645, KSU Agricultural Experiment Station and Cooperative Extension Service, https://bookstore.ksre.ksu.edu/pubs/MF2645.pdf, March 2004.

Minimum Standards for Design and Construction of Onsite Wastewater Systems: Bulletin 4-2, MF-2214, Kansas Department of Health and Environment and KSU Agricultural Experiment Station and Cooperative Extension Service, https://bookstore.ksre.ksu.edu/Item.aspx?catId=386&pubId=769, March 1997.

Wastewater Pond Operation, Maintenance and Repair, MF-2290, KSU Agricultural Experiment Station and Cooperative Extension Service, https://bookstore.ksre.ksu.edu/Item.aspx?catId=371&pubId=837, April 2005.

The following publications are available from other state Cooperative Extensions as indicated.

Individual Home Sewage Treatment Systems: Lagoons, AE 892, North Dakota State University, https://www.ag.ndsu.edu/publications/home-farm/individual-home-sewage-treatment-systems#section-25 February 1997.

Residential On-site Wastewater Treatment: Lagoon Design and Construction, G01-1441-A, NebGuide, U of Nebraska, Cooperative Extension, http://extensionpublications.unl.edu/assets/pdf/g1441.pdf, March 2010.

Residential Sewage Lagoon Systems: A Homeowner's Guide to Installation and Maintenance, WQ 402, U of Missouri, Extension, Columbia, MO, https://extension2.missouri.edu/wq402, March 1997.

Reducing Pond Seepage, G1555, November 1997, MU Guide, available from Outreach and Extension, University of Missouri - Columbia, Agriculture Building, Columbia, MO, 65211, https://extension2.missouri.edu/g1555, January 1998.

The following publications are available from the respective state environment agency as shown.

Assessing Wastewater Options for Small Communities in Kansas, Kansas Department of Health & Environment, K-State Research & Extension, Midwest Assistance Program, and Crawford County Health Department, on KDHE web site at http://www.kdheks.gov/nps/ww_options_manual/index.html, November 1999.

Lagoon Sewage Disposal Systems: It's Your On-site System, Operation and Maintenance Guide for Homeowners, Oklahoma Department of Environmental Quality, July 2003. https://www.deq.ok.gov/wp-content/uploads/environmental-complaints/Lagoon-.pdf

Figure IX-2. Gate and Fencing

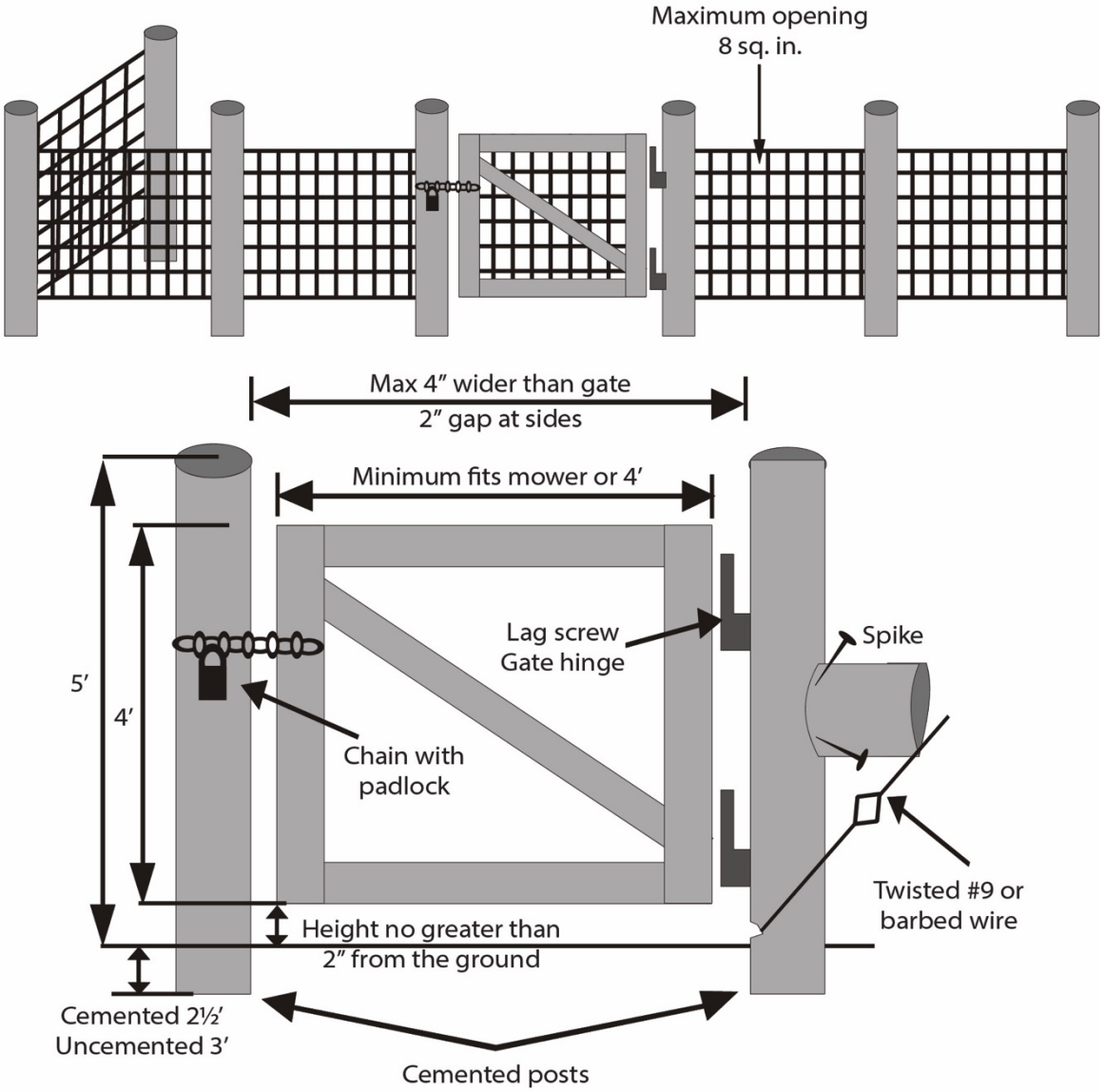
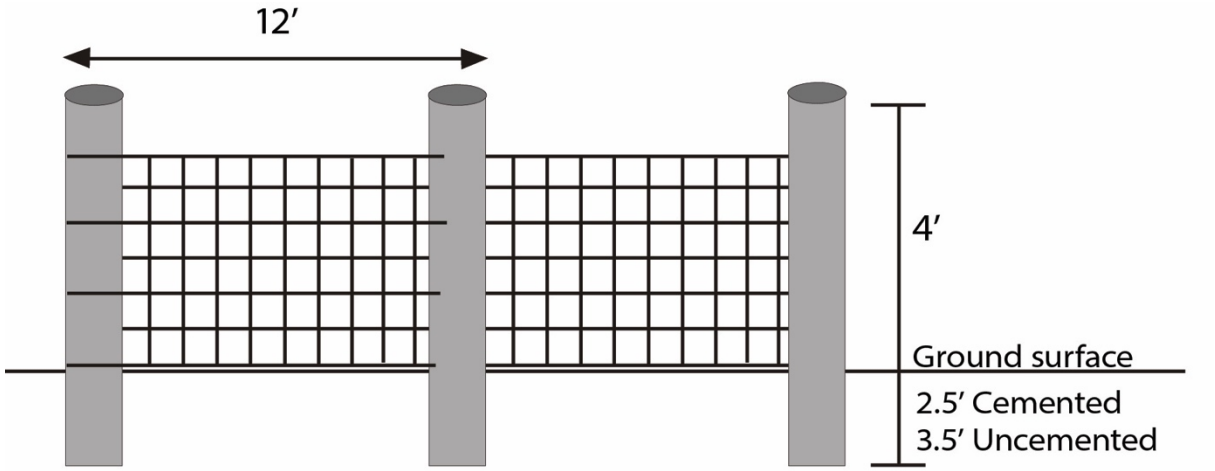


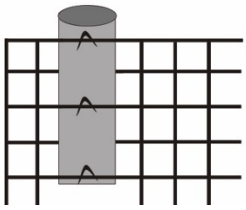
Figure IX-3. Fencing: The Standard Fence



Avoid driving staple in too far to prevent damage to wire.

Staple on slant to prevent post from splitting.

Staple top, bottom, and every 12 inches along post.



Use fence staples 1½" long

12½ gauge

2'x4' Welded wire or chain link fencing

Line post material: pressure-treated wood or standard steel fence posts

Figure IX-4. Fencing: "H" Style Corner Brace

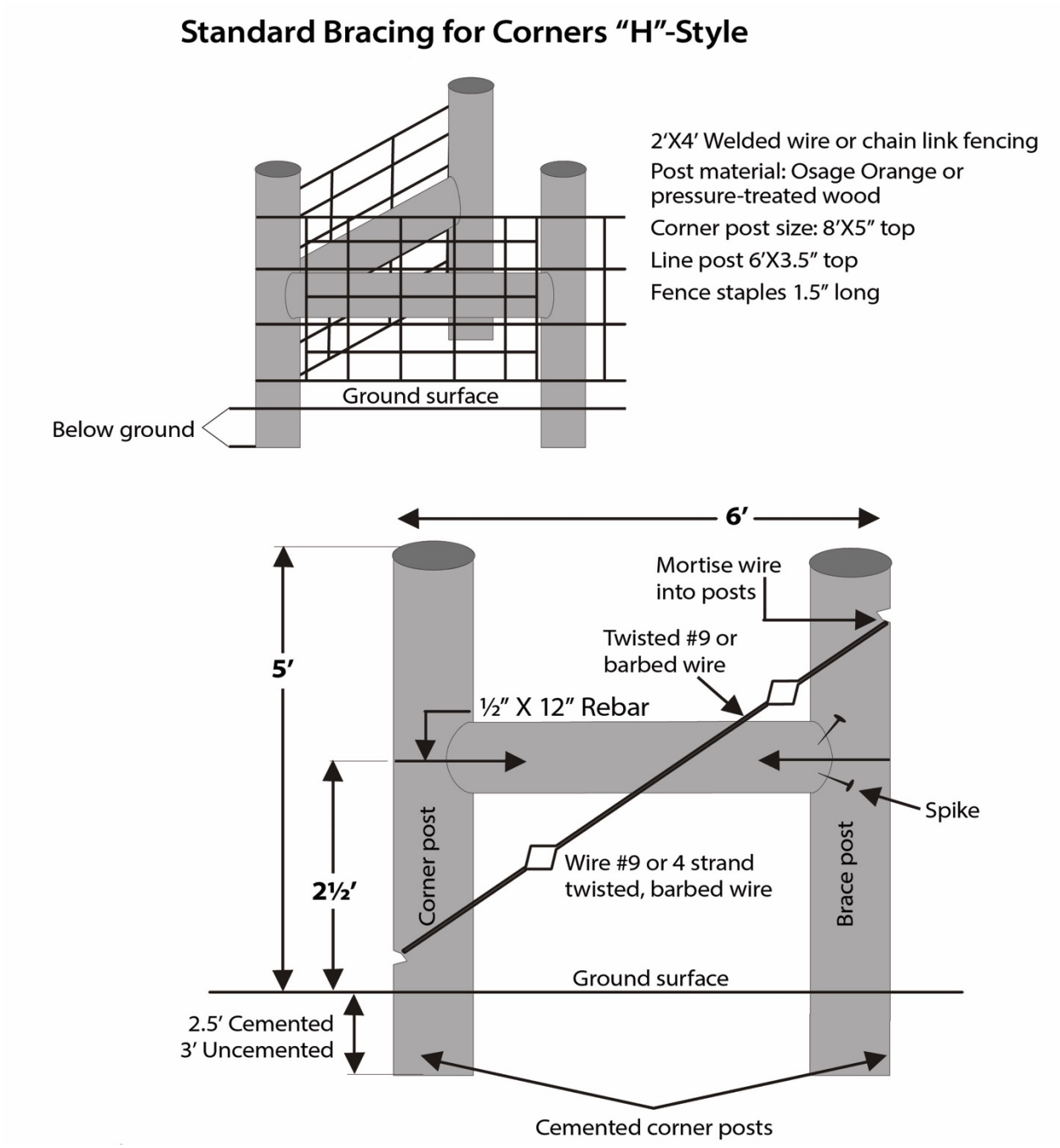


Figure IX-5. Fencing: "N" Style Corner Brace

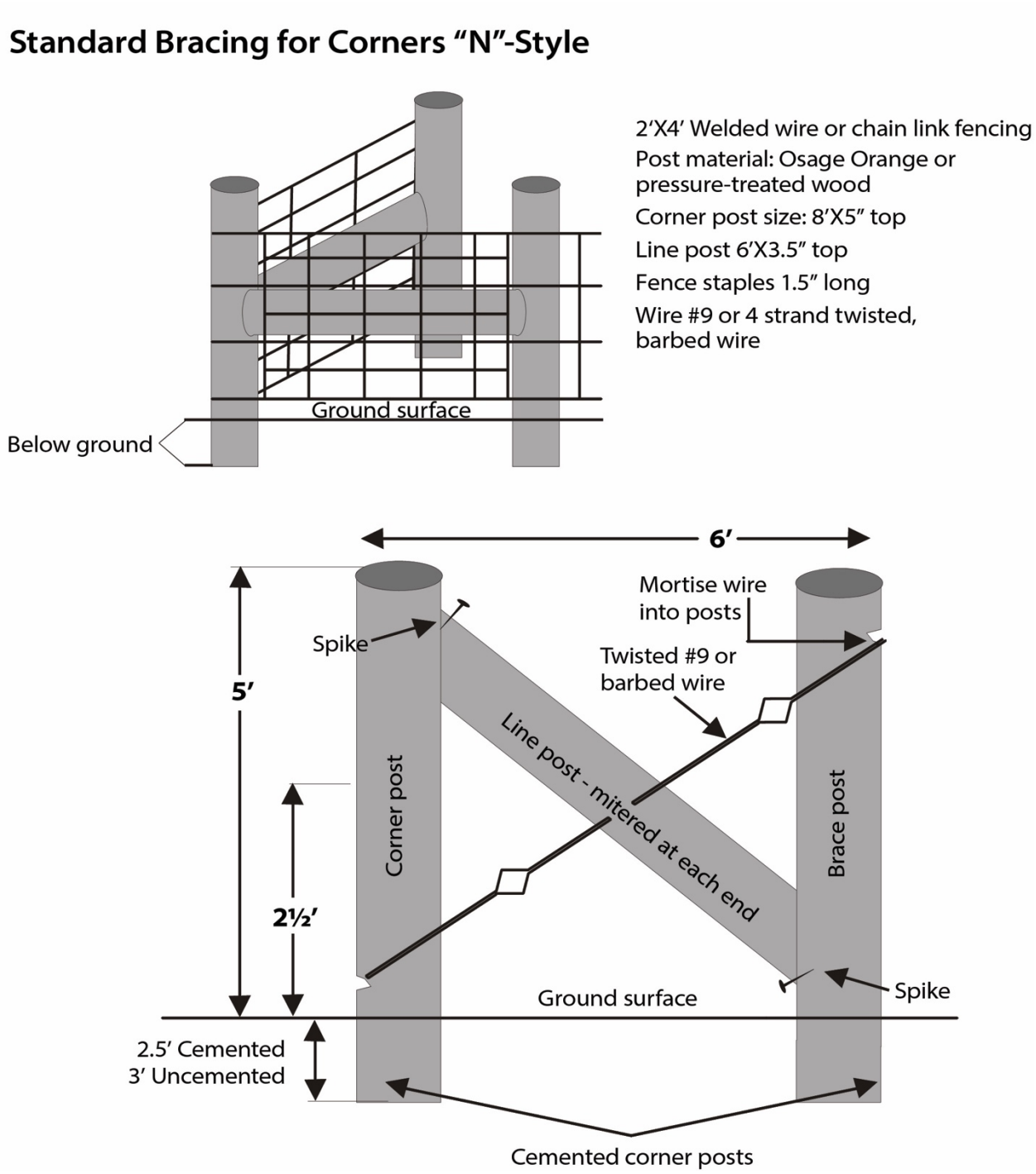
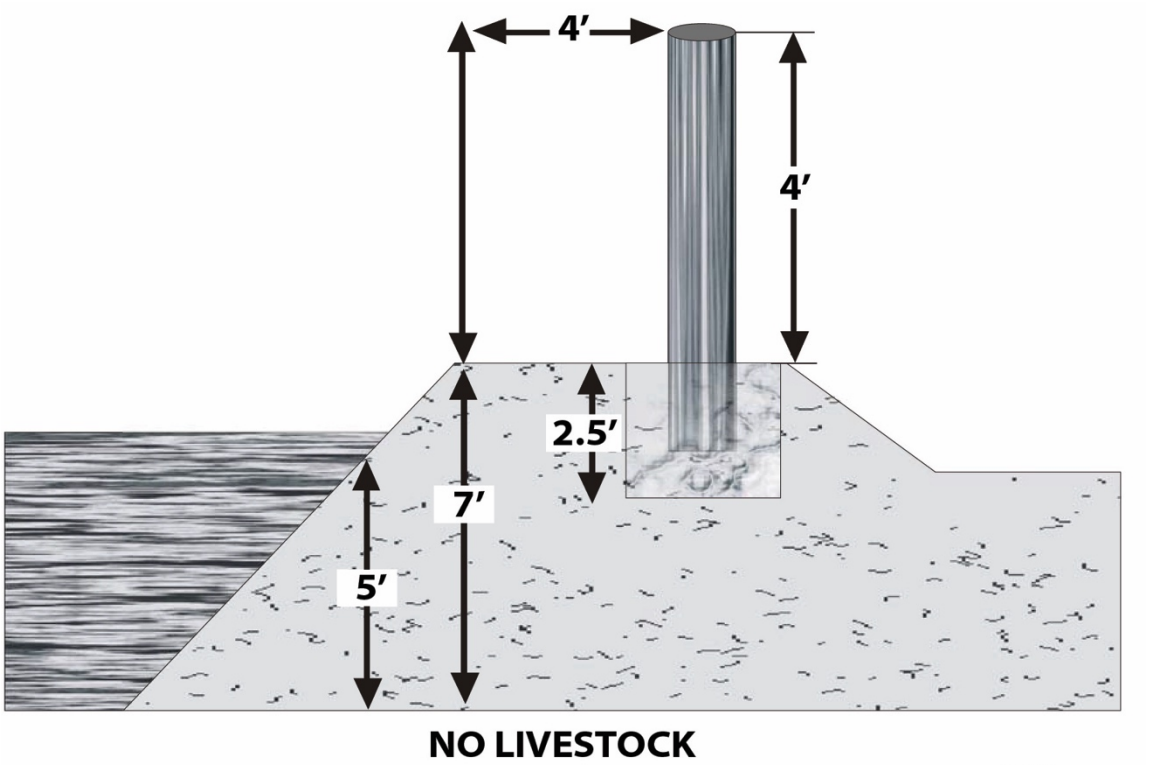
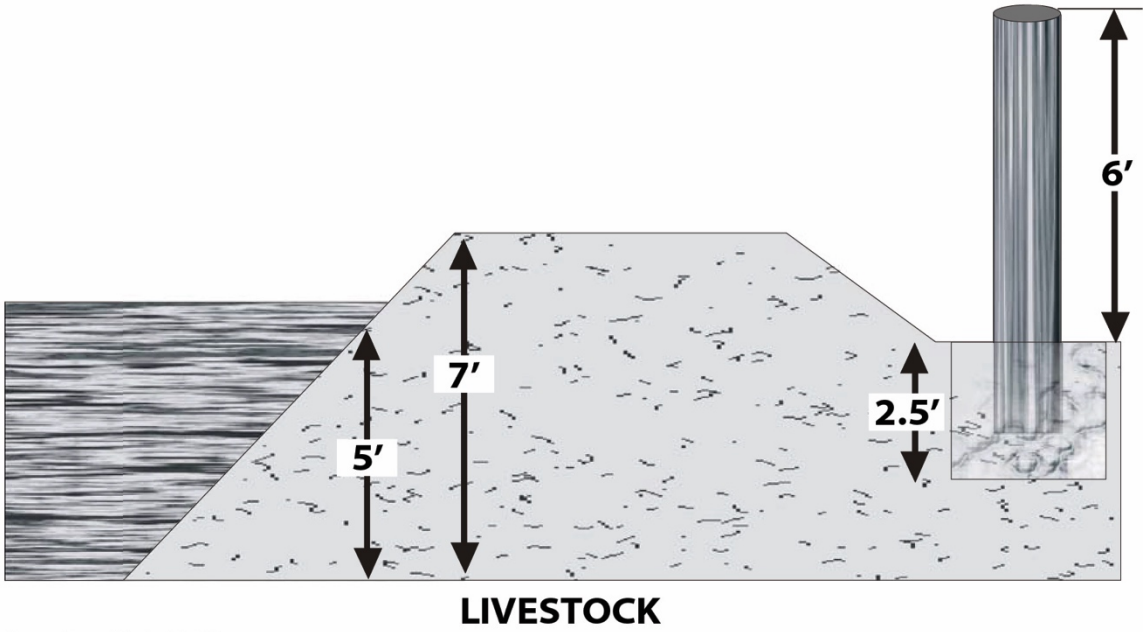


Figure IX-6. Fencing: Placement





Drawing: Chris McVey

Figure IX-7. Lagoon Siting and Design

PROTOCOL
PERMITTING AUTHORITY

GOAL: Determine regulatory authority and associated procedures covering construction and operation of wastewater lagoons.

POLICY: Local governments with a KDHE-approved sanitary code have authority to regulate small, nondischarging wastewater treatment lagoons. If the local unit of government does not object to the proposed project but does not choose to exercise the option to permit and regulate the lagoon, they must refer the owner to the KDHE Wastewater Permitting Section and notify that office.

PROCEDURE

Determine Regulatory Authority

The Kansas Department of Health and Environment has defined its responsibility for permitting wastewater lagoon systems that discharge to the surface, receive any amount of industrial wastewater discharge, or serve wastewater systems owned by a local government or other public entity. Authority to regulate wastewater lagoons is granted to local government under K.S.A. 19-3701 et seq.; K.S.A. 19-101a; K.S.A. 12-3302 or 3303; and K.A.R. 28-5-6.

Local governments may regulate wastewater treatment lagoons if all conditions specified in paragraphs 1 through 3 shown below are satisfied.

1) Local governments, which have a KDHE-approved sanitary code, have authority and may regulate small wastewater lagoons that receive domestic wastewater. Domestic sewage consists of wastewater originating primarily from kitchen, bathroom, and laundry sources including waste from food preparation, dishwashing, garbage-grinding, toilets, baths, showers, laundry, and sinks.

2) Local governments generally regulate wastewater lagoons to which less than 2,500 gallons per day (gpd) of domestic type sewage is discharged. Wastewater lagoons receiving more than 2,500 gpd of sewage (daily average) generally obtain a permit from the Kansas Department of Health and Environment.

3) All discharging lagoons require a permit from KDHE. Local governments may regulate only nondischarging lagoons.

Responsibility of Local Authority

If the local authority chooses to exercise the option to permit and regulate the lagoon, the local authority will approve plans, conduct inspections during construction, conduct periodic inspections of the property, and take enforcement action when necessary to maintain compliance with local government requirements for wastewater lagoons regulated by that local authority.

The local authority should also inform the customer that if a city or regional wastewater collection system becomes available, within 400 to 1,500 feet of the location, the local authority and/or KDHE may require connection to the central collection system and proper abandonment of the local wastewater treatment system.

If the local authority desires assistance from the Kansas Department of Health and Environment, the local authority should initially contact the appropriate district office (district environmental administrator or district water program staff) or the Topeka LEPP program staff person. LEPP staff will provide technical materials and other information as available to help support local government. KDHE district offices will provide assistance and advice, including backup inspections as requested by the local entity.

If the local unit of government objects to the proposed project, it should state the objections in writing to both the owner and KDHE to assure intergovernmental coordination.

If the local unit of government does not object to the proposed project but does not choose to exercise the option to permit and regulate the lagoon, they must refer the owner to the appropriate KDHE district office and notify that office.

Responsibility of KDHE

KDHE will inform the owner that the local authority has chosen not to accept local regulatory authority for the wastewater system (or for this particular lagoon, whichever is the case), and therefore, the customer is subject to state regulation. The Wastewater Permitting Section staff will take appropriate action.

PROTOCOL
EVALUATING AND SITING A LAGOON

GOAL: Determine if a lagoon system is well suited to the site conditions and determine the best location on the property for a lagoon. It should protect public health, assure safe wastewater treatment, and prevent contamination to the state's water supplies.

POLICY: Site and soil evaluation for a new wastewater lagoon may be completed upon a request of the landowner, realtor, contractor, lending agency, or other interested party and payment of necessary fees. Listed below are evaluation points for discussion during the inspection. All individuals who have legal interest in the outcome of the evaluation need to be provided with a report summarizing the assessment. Whenever a site is unsuitable, a letter documenting the reasons and offering alternative solutions, if possible, is recommended. Letters and documents need to be maintained on file for future reference.

PROCEDURE

1) Follow the code, and local regulatory agency policies and procedures regarding the application and site evaluation.

2) Evaluation may include an initial inspection visit to the property to meet with the owner and any other interested parties.

3) Inspect property and proposed lagoon site for conditions affecting location. Such conditions include, but are not limited to, wells, soil conditions, property lines, easements, depth to groundwater, and slope. The NRCS Web Soil Survey can be utilized to determine probable soil type and general suitability for a wastewater lagoon. Note: Conducting a soil-profile evaluation is the best method of assuring suitable soil conditions.

4) Mark the proposed lagoon location with flags, and take photos of the proposed lagoon site from each side and looking away from the site in each direction.

5) If site conditions have been evaluated as favorable for a wastewater lagoon, an application requesting a wastewater lagoon installation permit must be completed by the landowner.

6) Lagoon sizing can be done according to round, square, or rectangular designs (Refer to Table IX-1).

7) Instructions and diagrams for construction need to be provided in writing for agency files and a copy given to the landowner.

8) A permit to construct a wastewater lagoon shall be provided to the landowner. It is recommended the landowner be given a time limit in which construction is to be completed. The landowner needs to be instructed that delays that prevent completion by the agreed upon time will require the landowner to contact the inspector for an extension.

If an extension is not requested, the property owner may be required to reapply. It is the landowner's responsibility to contact the inspector for construction inspections.

9) Once the inspector has been notified that construction is complete, a final inspection needs to be made to assure compliance with county codes. Lagoon construction is not complete until the fence has been built. If construction is acceptable, a permit to operate shall be issued at that time.

10) Permit to operate shall state the regulating agency has the right to inspect the lagoon at any time it deems necessary to determine county code compliance.

PROTOCOL
INSPECTION OF EXISTING WASTEWATER LAGOON

GOAL: Determine system integrity in order to provide for safe public water and to prevent contamination of any water supply within the state.

POLICY: Evaluation of an existing private wastewater lagoon may be completed on the request of a lending agency, real estate agency, landowner, or complainant. A written letter summarizing the evaluation should be sent to all parties who have interest in the outcome of the evaluation. Possible parties may include, but are not be limited to, buyers, sellers, realtors, lending institutions, zoning boards, and contractors. When a system does not comply with county requirements, it is the responsibility of the inspector to determine the needed corrections. Proof of system correction and adequate operation must be established prior to approval.

EVALUATION

1) Acquire any previous records such as files of a permit, inspections, and contractor bills, and name and address of current property owner.

2) Information that may be appropriate for evaluation purposes —

   a) Identification of any additional features used in conjunction with the wastewater lagoon and the location of these additional features such as septic tank, holding tank, or devices altering the gravity flow of wastewater.

   b) Proof of where water lines are located (public or private).

   c) Receipts for septage pumping and/or herbicide purchase.

   d) Name and address for anyone not living in the household and served by the same system (i.e., two homes sharing the same lagoon).

   e) Location of any wells or cisterns used for potable and non-potable purposes.

   f) Easements for right-of-way which include the lagoon area.

   g) Number of persons presently and potentially served by system and an average estimated wastewater flow.

   h) Map showing location of sewage pipes, wells, potable water pipes, and improvements.

   i) Name of buyer with address and phone number.

   j) Real estate and/or lending agency's address and phone number, if applicable.

   k) Contractor name, address, and phone number or contact information for person constructing the system.

l) System maintenance person's name, address, and phone number, if applicable.

3) Examine water and sewage pipes where they exit the house and from the basement, if possible. Determine if all household wastewater is discharged into the lagoon.

4) Check cleanouts for proper flow of wastewater and location. They need to be located at every change of direction and within 100 feet of each other along a straight line. They should also be covered to prevent entry of water such as rainfall. It is desirable to have a combination cap and vent to allow dissipation of gases that may back up with a clogged pipe.

5) Measure the slope of the wastewater pipe from the house to the lagoon (should be 12.5 inches to 36 inches per 100 feet.) Determine if there is a possibility of backflow from the lagoon or cleanout during times of high lagoon water. A contractor's or engineer's level may be needed to give an accurate evaluation of potential backflow occurrence.

6) Fencing — check adequacy of height, spacing, strength, and safety measures such as a lock and posted signs to prevent unauthorized entry of humans or animals.

7) Berm evaluation — observe area for rocks, clods, ruts, groundcover, erosion, trees, tall weeds, accessibility to mowing machinery, ability to divert surface runoff away from lagoon, and presence of animals. Note any shading by adjacent vegetation.

8) Lagoon evaluation — check that a post with measurement markings at every foot is located near the lagoon center. Check that water depth is maintained between 2.5 feet and 5 feet. An absence of aquatic vegetation is an indication that water depth stays above 2.5 feet. There should be no foul odor. The color should be sparkling dark green, which indicates the pH is correct and there is adequate dissolved oxygen.

9) Surface area — measure the width of the lagoon at the operational level (five foot water depth) and determine the current surface area. The surface area of the system should reasonably correspond to the surface area indicated on the recommended model size.

10) Evaluate the outlet pipe. The pipe should enter the lagoon beneath the water level and extend to a point located near the lagoon center. The pipe end should be set at a height of approximately 1.5 feet above the bottom of the lagoon. A concrete pad should be placed under the pipe end to prevent lining damage from the force of wastewater discharge. Check that the end of the pipe is stabilized, such as being supported by concrete blocks and secured by chain or other means, to prevent movement and possible breakage.

11) Evaluate corrections and replacement considerations. Know how many years the lagoon has been in operation. Know if the lagoon has ever risen higher than the 2 feet of freeboard. Know if the lagoon ever overflowed. Know if the water level ever dropped below 2.5 feet. If there are indications of sludge build up, or undersizing of lagoon for amount of household wastewater discharge, consider what options exist to build a second cell or provide other system replacement. This needs to be documented on a map of the site. If the household has a relatively low amount of wastewater discharge for the lagoon

size, consider if it is feasible to add water from roof drains, sump pumps, or other sources.

12) Complete change-of-ownership papers on permit records if appropriate. Provide owners with a copy of the permit.

13) Two sample inspection report forms may be useful and are included later in this chapter.

PROTOCOL
EMERGENCY DEWATERING PROCEDURE

GOAL: Prevent overflow of lagoon due to temporary conditions such as extra water use or prolonged wet weather conditions.

POLICY: *Dewatering is not a normal operating procedure*; it is an emergency procedure that should only be used on rare occasions when the lagoon water depth is less than 2 feet below the top of the berm.

PROCEDURE

Occasionally, short-term conditions such as prolonged wet weather conditions or use of extra water may result in the lagoon level being higher than 2 feet below the top of the berm. This condition requires dewatering. Irrigation may be used to dewater the lagoon in such a situation. Dewatering is not to be considered a normal operating procedure; it is an emergency procedure to be used on rare occasions. If the threat of overflow persists, other measures must be taken such as enlargement of the existing lagoon or construction of an additional cell.

1) Excess water, without solids, should be pumped to a vegetated area through a sprinkler so runoff does not occur. Care should be taken to minimize taking up fresh or untreated sewage, and sewage solids with the irrigation water. The water intake should be about 8 to 12 inches below the water's surface. Perforated hoses, sprinklers, and sprayers can be useful but may clog if solids are present.

2) This water must be distributed so that it is all absorbed into the ground without runoff. Irrigation is not an option when the ground is saturated or frozen.

3) The area to be irrigated should not be within 50 feet of a property line not under the control of the facility owner or within 100 feet of a water well. The preferred irrigation area is relatively level, tilled cropland or grassland. People and animals must be kept out of the application area for at least 30 days. The irrigation area should not be used for children's play area, garden area, or be accessible to lactating dairy animals. Wait at least 30 days to harvest hay or graze animals in the area.

4) When the ground is frozen or already saturated, the acceptable alternative is to have the excess sewage hauled by a licensed septage hauler. Stringent water conservation practices should be used during such times.

5) The lagoon owner must get permission from the appropriate regulatory authority before dewatering.

PROTOCOL
SEALING A LEAKING LAGOON

GOAL: Determine the cause of seepage and implement a solution to stop it.

POLICY: The maximum allowable seepage is ¼-inch per day. Ideally, water in the lagoon should be maintained between 3 and 5 feet.

PROCEDURE

Excess seepage can lower the water in the lagoon to unusable levels. Seepage can commonly be attributed to areas of permeable soils in the bottom or sides of the lagoon. Different methods can be used to reduce the seepage. Before any investment is made in sealing a lagoon, an evaluation of the problem area by a trained soil scientist, engineer, or technician is beneficial. Contact the local Natural Resources Conservation Service and/or the county sanitarian for assistance on sealing leaking lagoons. Once the cause of seepage is reasonably determined, the best and most practical method for sealing can be chosen.

Sealing with earth blankets

Sites with too little clay to prevent excessive seepage can be sealed by an earth blanket compacted over the leaky area.

1) The best blanket material should have a good mix of particle sizes from small gravel or coarse sand to fine sand, silt, and clay in the desired proportions. The clay particles should make up about 20 % of the weight.

2) The area to be sealed should be prepared by draining the lagoon and permitting the area to dry.

3) The area should then be worked with a disc, tiller, or similar equipment and the blanket material uniformly spread over the area in 6- to 8-inch layers. Each layer should be thoroughly compacted by a roller before the next layer is placed. Generally, two or three layers is adequate.

4) For this method to be practical, a suitable borrow area should be close enough to permit hauling the blanket material at a reasonable cost.

Sealing with flexible membrane lining

This method, though generally expensive, is perhaps the most effective because it eliminates virtually all seepage when properly installed. Flexible membranes made of plastic, rubber, or similar materials are placed as impermeable liners in the bottom of the lagoon.

1) All membranes should be constructed of high-quality materials and should be certified by the manufacturer to be suitable for use as liners.

2) The area to be lined should be drained and allowed to dry until the surface is firm, and can support the people and equipment that must travel over it during installation of the lining.

3) All rocks, stumps, hard clods, and other materials that could damage the liner should be removed from the surface before the liner is laid.

4) The liner should be installed according to the manufacturer's recommendations and specifications.

Sealing with bentonite

Bentonite is a high-swell clay material suitable for use on soils having a high proportion of coarse-grained materials and insufficient clay. Bentonite absorbs several times its own weight of water and when completely saturated can swell 8-20 times its original volume. Bentonite can be purchased in bag or bulk as a powder or in pellet form. Farm supply stores, co-ops, or well drillers often supply bentonite.

1) The area to be treated must be drained and dried prior to applying the bentonite. (Dumping bentonite in the water in an undrained lagoon does not work and can have detrimental effects on the water quality.)

2) Bentonite is mixed with the existing coarse material soil. Rates of application vary from 1-3 pounds per square foot, depending on the site material.

3) The mixed soil must be thoroughly compacted. The saturated bentonite will swell to fill the voids and pores, sealing the lagoon.

4) Upon drying, bentonite returns to its original volume, so it is not usually suitable for lagoons with a wide fluctuation in water level.

Sealing with soil dispersant

Excessive seepage can occur in a lagoon even in clay soils because the clay particles are arranged to form an open, porous, or honeycomb structure. Applying small amounts of certain chemicals to these porous materials can disperse them and reduce soil permeability. These chemicals are referred to as dispersing agents.

1) Prior to application, the area should be drained and dried.

2) Sodium chloride (common salt), sodium tripolyphosphate (STPP), and tetrasodium pyrophosphate (TSPP) are all effective dispersing agents. Commercial phosphatic fertilizer should *not* be used. Farm and feed supply stores and co-ops often supply the proper type of salt or dispersing agent. The dispersing agent should be applied at a uniform rate and thoroughly mixed into each 6-inch layer treated with a disc or tiller.

3) Rates of application range from 0.05-0.33 pounds per square foot depending on the type of soil and type of dispersant used.

4) Each treated layer should then be thoroughly compacted.

PROTOCOL
COMPACTED LINING FOR SMALL WASTEWATER LAGOON

Purpose: Guidelines for lagoon construction where soils do not have extremely slow drainage and where it is shallow to bedrock (bottom of lagoon is less than a foot above or into rock).

Suitable Soil: Determine subsoil is at least 30 percent clay, either by determining soil texture or testing the soil to determine percent clay.

Construction Procedure:

1) Remove topsoil and stockpile it near the site for later use. Vegetation should be permanently removed and not used to construct the berm because it will eventually decay and cause soil settling.

2) Test to determine if soil is at or slightly above the plastic limit by rolling out a small clump of soil into a wire shape, 1/8-inch diameter or smaller, without breaking apart. If it breaks, it is either not wet enough or does not contain enough clay. Add water and test again. If repeated attempts are not successful, there may not be enough clay and the choice of a lagoon for this site should be reconsidered.

3) Remove the subsoil 12 to 18 inches below the bottom and sides of the lagoon and stockpile for reuse. When the bottom is shaped, measure the bottom area and, using a level, determine elevations near the inner corners and center. Measure horizontal distances from permanent reference points to the corners to verify thickness of the constructed lining.

4) Compact the bottom and side layer using at least four passes.

    a) A sheepsfoot or other full-coverage roller is preferred.

    b) If a sheepsfoot roller is not available, use a heavily weighted wheel tractor, making passes so there is complete coverage of the surface to equal one pass with a full-coverage roller. Given the small percent of tire to machine width, to get full coverage of the surface may require a total of 16 to 20 passes for each width of the tractor.

5) Add a layer of loose subsoil (clay) material and compact. If the amount of material removed is not adequate, a similar subsoil material must be imported to the site.

    a) If a sheepsfoot roller is used, add 9 inches of loose material and compact to a 5- to 6-inch thickness, or add 6 inches of loose material and compact to 3.5 to 4 inches.

    b) If a tractor is used for compaction, add 6 inches of loose material and compact to 3.5 to 4 inches.

6) Repeat step (5) until a 1.5-foot-thick compacted layer is constructed.

7) After the compacted liner is complete, finish final grade of the compacted bottom and sides of the lagoon to maintain the proper side slope. The interior slopes should be no steeper than 3:1; 3.5:1 is better.

8) Place the topsoil over the outside, top, and top-third of the inside of the berm.

9) Using field tests, verify that compaction has been achieved.

   a) Compaction makes the soil firm and it should be very difficult to insert a hand probe more than a few inches. This gives a good indication of compaction. KDHE recommends an electronic soil compaction meter (Field Scout or equivalent) to test compaction.

   b) To evaluate compaction of the entire liner thickness, use a 4-pound hammer to drive an 18- to 24-inch-long number 3 rebar 1½ to 2 feet into the lagoon lining. Count the number of blows to drive it for each 6-inch interval. The number of blows should increase with depth. The bar will be quite difficult to remove, so if removal is important, plan how to do this before you go to the field. If a shorter bar is used and left flush or slightly below the surface, removal is not essential.

PROTOCOL
HOME MAINTENANCE AND MONTHLY INSPECTION CHECKLIST

Conduct Inspections Monthly • Date of Inspection _____

Name and address of home occupant _____

Person conducting inspection _____ Date_____

Number of Occupants Served _____ Number of Bedrooms _____

Approx. Vertical Distance- water level to top of embankment _____

Water depth _____

Color

___ Dark sparkling green (best condition, indicates dissolved oxygen (DO) and pH high)

___ Dull green to yellow (not as good, indicates DO and pH less than optimum; blue-green algae may be becoming predominant.

___ Gray to black (very bad, anaerobic, or septic conditions prevail; odors likely. Too much sludge is possible.

___ Tan to brown (bad in Kansas where brown algae is not found, usually means erosion or inflow of surface water; okay if algae is brown).

Review: Mark lagoon deficiencies, provide any necessary details on back.

1) Lagoon area fence is strong and intact all around perimeter, keeping out children and livestock.
2) No evidence of lagoon discharging.
3) No surface drainage into lagoon.
4) No eroded or damaged berm in need of modification or repair. Slope should be no steeper than 3 to 1.
5) No vegetation height more than 6 inches.
6) Stand of groundcover on berms is adequate for erosion control.
7) No cattails or other vegetation growth in lagoon; no plants floating on water.
8) No tree or woody plant growth within 50 feet of lagoon, which produces leaf debris in lagoon, and/or blocks sunlight and airflow action on lagoon.

Name: _____ Date: _____ Title: _____

INSPECTION REPORT FORM: DATA FOR A SMALL LAGOON

Name of Owner _____ Phone_____

Address of Owner _____

Person(s) Contacted at Site _____

Legal Description S_____, T _____, R _____, County_____

Number of Occupants Served _____ X 50 gpd = _____ total gpd = Estimated Flow

Approx. Vertical Distance - water level to top of embankment _____

Horizontal Distance to nearest property line _____

Distance to property owner's nearest well _____

Review: Mark lagoon deficiencies, provide any necessary details on back.

CONSTRUCTION:

_____ Lagoon construction incomplete or substandard.

SIZING:

_____ Lagoon used by more than one household

_____ Lagoon not sized according to plans and specifications.

_____ Lagoon does not meet size requirement for number of people or estimated wastewater flow

LOCATION:

_____ There is not a potential site for a second system

_____ Lagoon is located on easement (type) _____

Easement Holder _____

_____ Lagoon located too near well(s) or weeds and trees

PLUMBING:

_____ Household is served by two or more disposal systems

_____ Greywater is not discharged into lagoon

_____ Sewer pipe slope is not within acceptable limits

_____ Berm is above the point where sewage exits house

_____ Outlet pipe does not terminate in approximate lagoon center

_____ Water from roof/patio/foundation drains enters lagoon

_____ Overflow pipe present

_____ Clean outs not properly installed/maintained

FENCING:

_____ Fencing/gate requirements have not been met

VEGETATION:

_____ Berm vegetation is over 6 inches high

_____ Floating vegetation present

_____ Cattails present

BERM:

_____ Berm does not have stand of short-rooted perennial groundcover

_____ Lagoon berm eroded/damaged/berm slopes not within acceptable limits

_____ Animals/farm machinery has access to lagoon berm

_____ Surface drainage can enter lagoon

OPERATION:

_____ Water depth not between 2 ½ feet and 5 feet

_____ Seepage present

_____ Lagoon overflowing

_____ Lagoon too shallow to prevent overflow

_____ Lagoon water used routinely for irrigation

_____ Lagoon overloaded

_____ Wave action sluggish or absent, indicating anaerobic conditions or an oily surface

_____ Evidence of siphoning or pumping

REGISTRATION:

_____ Application form incomplete

_____ Provide map of sewage/potable water pipes

_____ Lagoon is not registered with health department

_____ Change of ownership forms have not been received

_____ Required fees have not been paid

OTHER:

Name: _____ Date: _____ Title: _____