

## **Chapter 4. SMALL COMMUNITY WASTEWATER TREATMENT SYSTEMS**

### **A. Overview**

A small community has many alternatives to evaluate and select from for its wastewater collection and treatment. The choices range from the use of an individual septic tank/lateral field for each home and business, to gravity sewers and treatment plants that are miniatures of those used by larger communities. Small communities can also consider integrated combinations of more than one method.

#### ***Centralized, Decentralized, and Onsite***

A centralized system usually means a central treatment plant handling wastewater collected in gravity sewers with pumping stations as needed. An onsite system treats the wastewater generated by a single-family home or one business. The wastewater is treated and returned to the environment within the property boundaries of the home or business. A decentralized system is actually centralized in the sense that it has a central coordinated administration, but may have a common collection system and treatment facility or onsite systems or both.

#### ***Discharging vs. Non-Discharging***

A community needs to decide whether they want their system to be discharging or non-discharging. Discharging systems release the treated wastewater to the ground surface, usually into a ditch or stream. A discharging system requires a National Pollution Discharge Elimination System (NPDES) permit from the Kansas Department of Health and Environment (KDHE) and regular monitoring of the quality of the discharged water. A non-discharging system returns the wastewater to the soil (below surface) and to the air by evaporation or plant transpiration. Non-discharging lagoons that receive more than 2,500 gallons per day require a KDHE water pollution control permit.

Factors that are considered in making the discharging/non-discharging decision are size of the community (flow), ability of the local soils to absorb the required amount of wastewater, limitations on the stream receiving the water, and ability/desire to operate a moderately complex system. Discharging systems must use some type of treatment such as a sand filter, aeration system, package plant (pre-engineered mechanical unit), or a set of lagoons designed to be discharging systems, followed by disinfection, if needed.

#### ***Plant Size***

Another issue that must be addressed early in the planning is the ultimate number of homes that are to be served. In the movie, Field of Dreams, a major league baseball field is proposed in the middle of an Iowa cornfield. The question of who will fill the stands is answered with “If you build it, they will come.” The “Field of Dreams” factor applies to public works projects. If a community develops a good wastewater collection and treatment system at a reasonable cost, it will become a more desirable place to live and community growth very well may result. If the system is planned for a subdivision or a cluster of homes, the total number of available building sites will be an approximation of the ultimate size. However, if a system is to serve a community that wants or has the potential to grow, growth and the resulting requirement for oversizing and expandability need to be considered.

KDHE has a set of “Minimum Standards of Design for Water Pollution Control Facilities updated in 1978 that covers some of the community systems described here such as lagoons and

systems listed in Section J., Package Plants and Other Systems. If included in the Minimum Standards, a new system should meet or exceed these requirements.

## **B. Treatment Alternatives**

### ***Conventional Onsite Techniques***

Conventional onsite wastewater treatment methods can be adapted to small community-wide systems by increasing their size. Conventional onsite systems are those where wastewater exits the home or business and passes through a septic tank before it is treated in a soil absorption field. These absorption fields can be pipe-in-rock trenches, chambers, or beds, although beds are not recommended for large flows.

A small community that has onsite systems should give serious thought about whether their systems are failing and why. (Sanitary Surveys will be discussed in a later chapter.) Homes on very small lots in soils that are not very permeable may not be able to use onsite systems under any circumstances. However, it may be possible to use existing or repaired onsite systems with good management and careful use. It may be less expensive in both the near and long terms to make such modifications as low flow showerheads and faucets and even replacing toilets with low flow models and washing machines with front loading models that use less water, than to build a sewer system and treatment plant. It may also require lifestyle changes such as spreading out laundry washing over several days, giving up garbage disposals, turning off the shower while soaping, and regular septic tank pumping. However, community-wide cooperation in water conservation might be the only solution needed.

Another possible onsite alternative is the use of individual alternative systems such as aeration systems or sand filters. They are more expensive than conventional onsite systems, but may be less expensive than central systems. There will be later discussions of ways to manage these systems as a group to get the best performance and control costs.

### ***Shared Facilities***

It is possible that a small community is close enough to the existing wastewater treatment facility of another town that it is less expensive to convey wastewater to that treatment plant than to build a new one. If the existing plant is near capacity, they may not be able to accept additional wastewater. However, if an expansion is possible, the town may be willing to accept the small community's wastewater, if the community is willing to pay all or part of the expansion costs.

### ***Lagoons (Wastewater Stabilization Ponds)***

Lagoons, also known as wastewater stabilization ponds, are open ponds where wastewater is treated by bacteria using oxygen in air provided by wind motion, algae, and for community-sized lagoons, usually mechanical aeration equipment.

### ***Alternative (Enhanced) Treatment Methods***

Alternative treatment systems, such as sand filters and aeration systems, provide treatment for the removal of organic material and some pathogens from the wastewater before discharge or absorption. These units can be adapted and scaled to handle the full size range from single-home onsite systems through municipal plants.

### ***Package Plants***

Small package plants are commercially-made units designed for wastewater treatment that can be brought to a site and installed. Examples of systems used in package plants are rotating biological contactors and sequencing batch reactors. The package plants will include auxiliary equipment such as pumps and filters needed for operation. Package plants are usually larger and more complex than the systems described as alternative treatment. However, for larger flows or complex wastewaters, they may be more effective. They may also take up less space. They require more operator attention and higher-level operator training and commitment.

### **C. Conventional Soil Treatment And Subsurface Water Absorption**

The individual or shared absorption fields will be sized on the basis of flow and loading rates for the soil. Thought should be given to dividing the field into sections so that if there is a problem with one part of the field, the flow can be diverted to the rest. A rotational program of section use allows part of the field to rest and rejuvenate periodically. A rule of thumb is to limit the size of any section to 1,000 linear feet or less of lateral line. The standards for field sizes, trench design, and material and construction specifications for onsite systems in *Bulletin 4-2: Minimum Standards for Design and Construction of Onsite Wastewater Systems*, pp. 10-13, are also applicable to small community absorption systems. This document can be obtained from KDHE by Calling (785) 296-4195.

### **D. Lagoons (Wastewater Stabilization Ponds)**

Lagoons can provide both aerobic and anaerobic treatment zones of suspended bacteria. Two or more lagoons or cells are used for community systems. With three or more cells, the wastewater can flow from one cell to the next to the next (in series) or directly into two or more and from those cells into another cell (in parallel). Wastewater lagoons must be fenced. Wastewater lagoons take *relatively* little maintenance (not the same as *no* maintenance): keeping weeds out; the berms mowed and in good condition; and the mechanical equipment, pipes and valves in good operating condition. However, the lagoons should be inspected at least every two to three days to make sure that nothing has upset the processes going on in the lagoons and that the equipment is operating. Quick action to restore correct conditions is critical to prevent more maintenance problems, difficulties in restoring operations, and odors. (See Figures 1 and 2)

### **E. Sand Filters**

There are two types of sand filters, intermittent and recirculating. In an intermittent sand filter, the wastewater passes down through the sand bed once before going to an absorption field or discharge. Intermittent sand filters are further subdivided into buried and open. As a rule, intermittent sand filters for single homes or small clusters are buried and large sand filters are open. (Figure 3)

In a recirculating sand filter, part of the effluent from the filter goes to the absorption field and part is sent back to a recirculation tank ahead of the filter where it is mixed with septic tank or primary treatment effluent before being passed through the filter again. A recirculating sand filter is more expensive and complex than an intermittent unit. However, it can treat the wastewater more completely, and it can be designed to reduce total nitrogen and nitrates in the effluent, which is especially important for systems that discharge to a water-quality-limited stream. (Figure 4)

One of the most critical factors in good sand filter performance is the quality of the sand. It must be clean and sized to specific standards. Other key factors are how often and how much

wastewater is applied at a time. Sand filters require dosing which is applying wastewater during several short periods of time rather than continuously. This requires a pump and a timer.

Maintenance requirements for sand filters are to care for the pumps and other mechanical equipment. Those filters that have exposed sand surfaces may have to be raked periodically to keep the surface smooth and to remove surface clogging. Over the long term, some or all of the sand may have to be replaced. The orifices (spray holes) in the distribution lines need to be checked to be sure none are plugged and cleaned, if necessary. In extreme cases, sand filters may be restored by injecting air through the sand from the bottom of the filter.

#### **F. Non-Sand Filters**

Filters using media other than sand are in various stages of development. Other media include peat, synthetic fabric strips, expanded shale, and bottom ash. So far, use of the other media has been limited to single residences or very small clusters. Research for more effective or less expensive media is ongoing.

#### **G. Constructed Wetlands and Rock-Plant Filters**

As opposed to single residential systems, all, or almost all, constructed wetlands in small community systems are used for “polishing” (additional treatment) after other treatment. Rock-plant filters are similar small-scale systems used for treating septic tank effluent.

Unless gravity flow is not sufficient and pumps are needed, rock-plant filters do not have mechanical parts except a simple manual device to control water level. Maintenance is composed of keeping the plants in good condition and maintaining the water level at an adequate level to keep the plants in good condition. Dead plant material should be removed so that it does not add to the organic load in the system. (Figure 5)

#### **H. Mounds**

Mounds are similar to sand filters in that they have dosed distribution onto a bed of sand. However, a mound has a self-contained water dispersal system because the base of the mound is in contact with the soil that accepts the treated wastewater. Mounds are alternative treatment systems suitable for areas with high bedrock or water tables. Mounds can be used for small community systems. However, because of size and construction costs, they will probably be cost-competitive only for individual homes/facilities within a larger management district or for small clusters of homes. (Figure 6)

#### **I. Aeration**

Some alternative treatment systems, most package plants, and larger systems add oxygen by adding air to the wastewater to stimulate some chemical reactions and to increase bacterial activity. A variety of blowers, bubblers, or agitators can be used. Most very small systems have a fixed “medium” that the bacteria grow on. Some are plastic grids or balls, others are fabric “socks”. Power consumption may be higher with aeration units than other systems. Noise from the equipment may also be an issue.

Aeration systems also have equipment, such as fans, that will need to be maintained. The outer part of the bacteria layer on the media will slough off periodically. This material must be removed from the system. In some units, it can be pumped out by a septage hauler. In others, mechanical cleaning devices are required. (Figures 7 and 8)

## **J. Package Plants and Other Systems**

Wastewater treatment that does not use onsite-type technology uses some variant on a method that gradually separates the solids from the liquid and treats them. (Note that “solids” can mean anything that is solid after the water is evaporated, so wastewater contains “dissolved solids” as well as the ones that are visible.) The solids that remain at the end of the process form sludge, also known as biosolids.

### ***Activated Sludge***

There are a number of treatment methods that fall in the category of activated sludge processes. In an activated sludge process, the wastewater is treated in a tank, usually with aeration. Following this treatment, the wastewater is transferred to another unit where the sludge produced is separated from the effluent. Part of the sludge is returned to the treatment tank and the rest is removed for disposal. The returned sludge increases the concentration of active bacteria in the main treatment area.

### ***Extended Aeration***

In extended aeration, the detention time for the aeration process is 24 hours or longer versus less than an hour for some of other systems.

### ***Contact Stabilization***

In a contact stabilization process, the returned sludge is reaerated before it is added to the first aeration tank. This allows the first aeration tank to be smaller than for other processes.

### ***Oxidation Ditch***

The oxidation ditch uses a ring or oval channel instead of a rectangular tank to get a long reaction area in a small space. It is equipped with aeration devices. (Figure 9)

### ***Sequencing Batch Reactor***

Instead of series of tanks that the wastewater enters one after another, a sequencing batch reactor (SBR) performs each step in the same tank. More than one tank is used to handle larger volumes. The sequence is: fill, react (aerate), settle, draw (remove most of the wastewater), and idle. (Figure 10)

### ***Rotating Biological Contactors***

Rotating Biological Contactors (RBC) are a series of plastic disks on a rotating shaft mounted over a tank of wastewater. During rotation, a point on a disk will alternately dip into a tank of wastewater and rise into the air. The disks are covered with a film of bacteria that treats the wastewater. Aeration occurs by direct exposure to the air when the disks leave the wastewater. (Figure 11)

### ***Trickling Filters***

A trickling filter is a bed of media, traditionally rocks, but more recently plastic grids or balls. Wastewater is applied to the top of the filter, usually by spraying from a rotating arm. The spraying adds air and a bacterial film on the media treats the wastewater. (Figure 12)

## **K. Special Soil Absorption Systems**

In addition to conventional dispersal systems, wastewater can be pumped into the soil on a dosed

basis. Dosing provides two main advantages: it allows the soil to “rest” or to not be covered by effluent part of the time which allows the system to be more aerobic, and it covers the entire field area with effluent each time a dose is applied so all the area is used to the maximum.

### ***Low Pressure Pipe***

Low pressure pipe (LPP) systems typically use plastic pipes 1 to 2 inches in diameter with orifices (small spray holes) spaced 2.5 to 7.5 feet apart. A pump delivers effluent throughout the system on a regular basis as determined by a timer or the pump tank capacity.

### ***Drip Irrigation***

In drip irrigation, treated and filtered effluent is applied through shallow, flexible small-diameter tubing. The spacing of the tubing is about 2 feet apart and the very small orifices are also spaced two feet apart. Dosing is similar to LPP. Because of the flexible tubing and the shallow depth, drip irrigation is useful where the absorption field is an odd shape or if a restrictive layer is relatively high.

### **L. Reasons for Failure**

Time and time again, the reason for failure of wastewater treatment systems, whether onsite or central plants, is lack of maintenance. Other reasons are inadequately trained or careless operators, poor design, poor quality of equipment or construction, and changes in the flow rate or content of the wastewater that is not adjusted for by the treatment facility.

### **M. Factors for Success**

Success can be achieved by taking the reasons for failure individually and correcting them:

#### ***Maintenance***

Whether the treatment system is based on single-unit conventional onsite systems or central treatment plants, maintenance must be performed on a regular basis, or systems will deteriorate both in physical terms and in performance. Maintenance items can include:

<b>System</b>	<b>Typical Inspection and Maintenance Items</b>
Septic Tanks	Check sludge and scum depths (to determine need for pumping), repair or replace damaged baffles, clean or replace effluent filter, check and repair other damage or leaks
Absorption Fields	Protect from damage and traffic, alternative fields if using more than one section.
Lagoons	Remove vegetation from edges of lagoon, mow berms, check and repair erosion at edges, remove trees or shrubs shading lagoon, check and repair fence, check and repair equipment.
Pumps	Test pump cycle through full range of levels; test float controls; check pump and wiring for corrosion; clean grease or debris from floats, pump, screens, etc.
Other Mechanical Equipment	Follow Manufacturer's instructions and Designer's Operation and Maintenance Manual (When contracting for design of facilities and purchase of equipment, specify that these be supplied.) Check for corrosion, wear, or damage. Repair or replace parts as needed. Be sure that equipment is clean.

### ***Personnel***

Operators must be adequately trained to do their jobs. For the simpler onsite systems, inspections, pumping, and repairs can usually be learned by on-the-job training, assuming someone knowledgeable is there to teach it. This includes Local Environmental Protection Program or County Health Department personnel. More complex plants require trained and state-certified operators. KDHE administers the certification program and information can be obtained by calling (785) 296-5511.

### ***Design and Construction***

Before an engineer is hired and all the way through the design and construction process, the community needs to know what their goals are in terms of construction costs versus ongoing costs, simplicity versus complexity of operation, flexibility in the system, etc. These must be communicated to the engineer and the contractor and they must be monitored to be sure that the goals are being met as well as possible. Hiring a construction inspector who does not work for the contractor and who understands how a plant should be run can help in getting a system built well.

### ***Keeping Up with Changes in Wastewater and Regulations***

Being handed the key to the new plant by the contractor is not the end, but the beginning of successfully handling the community's wastewater. Among the biggest challenges in managing a small community wastewater system are staying current with changes in the community and

the resulting changes in its wastewater, and learning about and responding to changes in regulatory requirements. As the population grows or declines, or if new kinds of businesses connect to the system, changes in the operation of the system may be required. Monitoring the performance of the system and keeping good records will help identify when changes are required. However, advance planning is even better. Additional water quality tests or even higher quality effluent may be required a regulatory agency. Someone needs to stay on top of these things.

### ***Other Factors***

In addition, there are other less tangible factors for success. Long-term commitment of the community to providing good quality wastewater treatment is perhaps the most important. The monetary costs must be met and personnel must be found and properly trained. These challenges will last as long as the community provides wastewater service.

Imagination and cooperation will be useful tools. If ways of sharing equipment or personnel with other agencies can be found, the community's share of the costs can be reduced. For instance, it may be possible to contract with a rural water district or a rural electric association to do the billing. Another possibility is to have a "circuit-riding" operator who can work at more than one community's wastewater system. Usually a full-time operator is not needed at each plant, so the same person can handle several plants if they are fairly close to each other. Similarly, water plant operators for a water district could also be certified as wastewater plant operators. At the least, cooperative agreements could be reached to back up other operators during emergencies or vacations.

### **N. Selection Criteria**

The following factors need to be taken into consideration when selecting a wastewater treatment process for a community:

1. Effluent Water Quality Requirements (for Discharging Systems)
2. Flow Rate
3. Cost
4. Available Space
5. Availability of Equipment and Parts
6. Availability of Operators and Repairmen
7. Discharging vs. Non-discharging
8. Flexibility for Process Changes or Expansion
9. Preference
10. Local Topography/Geology

### **O. Special Considerations in Design**

#### ***Flow Rates/Plant Sizing***

Among the factors to be considered in selecting a method of treatment, are the flow rate (average and minimum/maximum) and the strength (chemical composition/concentration) of the

wastewater. There are typical assumptions used in engineering calculations. However, small communities may have special situations, such as the type of collection system, that will require making sure these assumptions are correct for that community. If a community has businesses or industries that are large water users, or if it has an unusually high number of businesses or industries for its size, detailed flow calculations should be made to account for them.

If the collection system has a conventional gravity sewer, a factor for infiltration and inflow (I & I) must be added in. Infiltration is water that enters the collection system through loose pipe connections, broken pipes or manholes. It is usually highest after rain or snow melt. If the water table is high, it may be a continuous problem. Inflow is water from sources such as foundation and roof drains, cooling water from air conditioners, and drainage from outdoor paved areas that have been connected into the sewer system. The KDHE requirement for new gravity sewer that is less than 24 inches in diameter is a maximum infiltration of 250 gallons per day (gpd) per mile of pipe for each inch of pipe diameter. (As an example, an 8 inch diameter pipe that is 2 miles long could have a maximum infiltration rate of 8 inches x 250 gpd x 2 miles = 4,000 gpd.) Older sewers can have much higher levels of infiltration. Inflow is possible with systems having septic tanks or grinder pumps, but it would probably be more noticeable in terms of overload or failure.

A pressure sewer, in order to stay pressurized, must be constructed more tightly than a gravity sewer. Therefore, infiltration should be minimal. However, past experience with alternative collection systems indicate that I & I can still be an issue if the system is not constructed well. Sources of infiltration can include septic tanks and pump chambers that are not watertight, loose connections on the pipe between the house and the septic tank, and leaky manholes. If assumptions about reduced wastewater flow because of the use of pressure sewers are to be valid, special attention during construction and maintenance must be paid to eliminating sources of infiltration.

### ***Strength of Wastewater***

The strength of wastewater varies from home to home and with time of day. This is a challenge for onsite systems that is dealt with by making conservative assumptions for typical wastewater to be used in design. In a community situation, the wastewater streams combine and the differences level out. However, the type of collection system influences the strength. As was described above, a conventional gravity sewer will have an I & I component. A pressure sewer will have to be tighter so the infiltration will be less. A substantial portion of the organic load is removed by a septic tank, so the strength of wastewater in a STEP (Septic Tank Effluent Pump) system would be lower than total household wastewater. On the other hand, the effluent from a grinder pump system will contain all material from household's wastewater. Because it will have lower I & I, it will be stronger than the wastewater from a gravity sewer. The design of a plant will need to be checked to be sure that it can handle the organic load as well as the hydraulic load.

### ***Denitrification***

A water quality standard that may become increasingly important for wastewater plants is the nitrogen level of the effluent. The important nitrogen compound in groundwater is nitrate and the important one for surface water is ammonia. Some systems reduce nitrogen levels as part of the process such as some recirculating sand filters and some commercial aeration units. Other systems can have an additional treatment unit added to the facility to remove nitrogen. If

nitrogen control may become an issue, a system should be selected that reduces nitrogen compounds or that can be easily modified to handle them.

***Septic Tank Abandonment***

If a decision is made to replace or abandon septic tanks, the existing tanks must be cleaned and properly abandoned, usually by breaking the bottom, and possibly the sides, and filling with compacted soil or other inert material. Other inadequate or illegal systems such as cesspools and “ratholes” must also be abandoned. In some circumstances, additional measures may be required. The costs of this procedure must be included in the project costs.