Choosing a Wastewater Treatment System

Part One of a Series About Onsite Wastewater Treatment Alternatives

Table of Contents: Choosing a Wastewater Treatment System

A Series About Onsite Wastewater Treatment Alternatives

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Introduction: What is an Onsite Wastewater System?

Finding a solution for waste removal was simpler when the choices were connecting to city sewers or living in the country with a backyard septic system. The standard septic system design first appeared in the 1950s to reduce disease and ***dispose*** of wastewater. By 1970 many states, including Rhode Island, had adopted minimum septic system design standards. Approximately 25 percent of U.S. homes, and about 30 percent in Rhode Island, still depend upon onsite wastewater treatment systems, and some towns are entirely unsewered.

For most of those homes and businesses, sewers simply may be unavailable, extending sewer lines may not be cost effective, or communities may be restricting sewer service in an effort to direct growth to existing urban centers. Sewers are no longer considered the most environmentally sound solution. Growth attracted by sewer capacity brings polluted runoff, and groundwater recharge is lost to treatment plants or leaking sewer lines. **Once considered a temporary fix until sewers could be installed, managed onsite treatment systems are now recognized as a permanent treatment solution.** When properly designed, installed and maintained, onsite treatment systems are often the best choice in many areas from both an economic and an environmental perspective. Due to advances in technology, a wide spectrum of alternative systems exist. These new technologies focus on ***treating and dispersing*** wastewater for recycling to groundwater.

This manual illustrates the range of both conventional and alternative onsite wastewater treatment technologies that are available to individual property owners and communities. Today's conventional septic system - still very similar to the 1950's model - remains the simplest, low-maintenance and low-cost choice for low density development with good soils and favorable site conditions. For difficult sites, including places where country living has grown more crowded, advanced treatment systems offer solutions that can:

- Replace a failing system where a conventional septic system is unsuitable.
- Enable homeowners to overcome site constraints.
- Retain existing landscaping and full use of property.
- Maintain natural and architectural features that give individual lots and neighborhoods unique scenic character.
- Protect critical water resources.

This manual is the first in a series about wastewater treatment systems. The chapters that follow provide information about various treatment options including conventional and substandard systems, modifications of those systems, alternative treatment technologies, and shared cluster systems. As each of those treatment choices are highlighted, it is important to consider site factors such as land area requirements and the ability of that system to meet water resource protection needs. The final chapter offers a simple framework, designed to guide the complex process of choosing the most appropriate wastewater treatment system.

Onsite wastewater treatment systems were once thought of as a temporary solution until municipal sewers could be installed. Today, many types of development rely on onsite systems, including village-style communities (above, left) as well as the traditional single family homes on a large lot (right).

Glossary

To minimize confusion, the following definitions are offered for the terms used in this introduction and throughout the manual.

Biochemical Oxygen Demand (BOD) – a commonly used measurement of the concentration of biodegradable organic impurities in wastewater. The amount of oxygen, expressed in milligrams per liter (mg/L), required by bacteria while stabilizing, digesting, or treating organic matter under aerobic conditions is determined by the availability of material in the wastewater to be used as biological food and the amount of oxygen used by the microorganisms during oxidation.

Cluster Wastewater Treatment System- an onsite wastewater collection and treatment system that serves two or more homes. Cluster systems serving a small number of homes may also be referred to as "shared" systems.

Drainfield - part of the septic system; the area of ground and system of subsurface pipes or chambers into which partially treated wastewater from the septic tank or alternative system is discharged for final treatment and absorption by soil. Also called a leachfield or absorption field.

Footprint – the area of disturbance created by a system.

Holding Tank or "Tight Tank" - a closed, watertight structure designed and used to receive and store wastewater. A holding tank does not discharge wastewater to surface or ground water or onto the surface of the ground. Holding tanks are designed and constructed to transfer wastewater to another site for treatment.

Large Flow Systems- industrial or commercial onsite wastewater treatment systems, or systems that serve more than a few residences, that handle larger volumes of wastewater compared with individual onsite systems (but whose volumes are small relative to most municipal sewer systems). May include systems with a design flow of 2,000 – 5,000 gallons per day or greater, with lower flows included in environmentally sensitive areas. Systems with flows in excess of 10,000 gallons per day are regulated by the EPA as Class V Injection Wells.

Onsite Wastewater Treatment System- a system that relies on natural processes and/or mechanical components that are used to collect, treat, and disperse or discharge wastewater from a single dwelling or building. May include systems that range in complexity from a septic tank and drainfield to a variety of alternative technologies.

Organic Material – carbon-based waste contained in plant or animal matter and originating from residential or industrial sources.

Slurry – A thin, watery mud or any substance resembling it.

Total Suspended Solids (TSS) - the amount of insoluble solids floating and in suspension in wastewater. Also referred to as total nonfilterable residue.

Important Notes About This Manual

The onsite wastewater treatment field is evolving rapidly. Systems considered state of the art today, may be outdated tomorrow. As a result, this manual focuses more upon the basic function, siting, and treatment issues raised by each type of system than upon the specific design and operation features of each technology. The technologies are described using the concept of "treatment trains," where additional treatment units can be added, as needed, to provide more specialized treatment.

When discussing alternative technologies in this manual, the authors use the Rhode Island code as an example. However, the type of wastewater treatment technologies permitted varies widely from state to state. Before applying any of the examples used in this document, the reader is encouraged to check with state or county officials regarding rules for drainfield size reduction and use of alternative technologies.

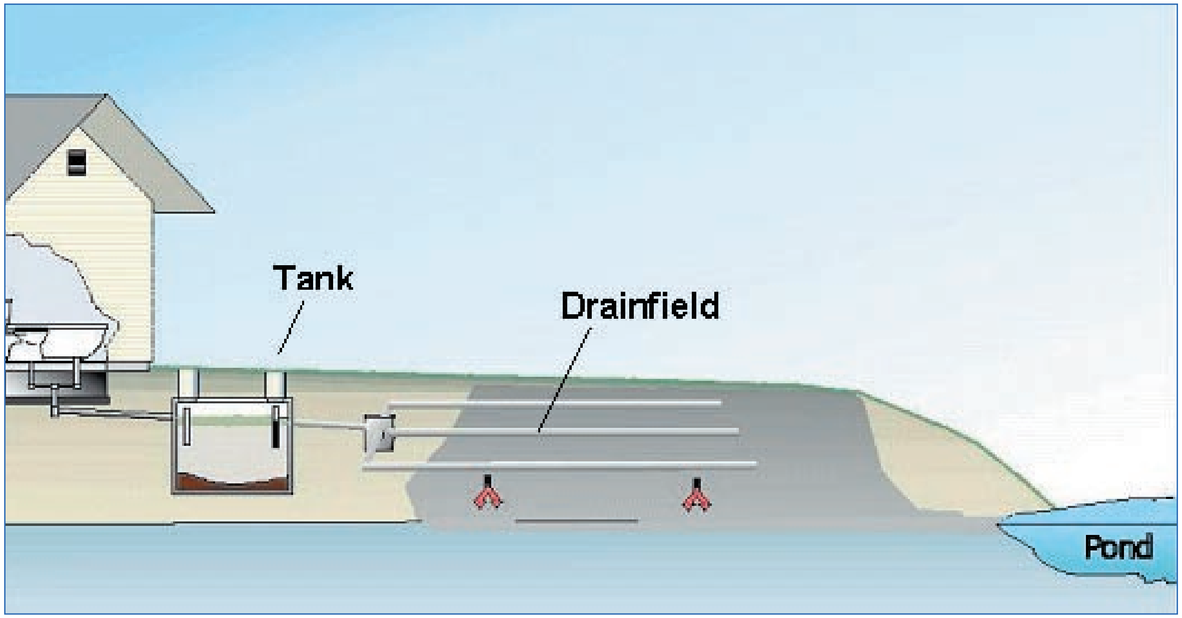
It is also important to recognize that some sites are unsuitable for development using any type of treatment system. When using advanced treatment systems to develop sites that may not be approved for conventional wastewater treatment systems, extreme care should be taken to ensure that other development impacts are adequately controlled.

When properly designed, installed, and maintained, conventional wastewater treatment systems can be a simple, low-cost, and environmentally sound treatment option for low intensity development. Their main limitation is that they rely on good soils and sufficient land area to treat or dilute waste. Also, poor construction, improper use, lack of maintenance, outdated systems, poor soil conditions, poor initial site assessment, or densely settled neighborhoods can all lead to expensive repairs, unsanitary conditions, and reduced water quality.

How Do They Work?

The basic elements of a conventional wastewater treatment system are a septic tank and a drainfield, also called a leachfield. The septic tank receives wastewater generated in the house and traps the solids, allowing only liquid waste to exit through the tank outlet pipe. As wastewater enters, the same amount leaves the tank by hydraulic displacement, flowing by gravity to the leachfield. A distribution box, or D-box, may be used to split the flow as equally as possible to all parts of the drainfield.

The actual look of a drainfield can vary considerably, but the most commonly used type is a series of perforated PVC pipes laid in stone filled trenches. Wastewater seeps out of the pipe, through the stone, and into the surrounding native soil material. It is the soil environment with all of its living organisms, oxygen, and physical and biochemical properties that actually treats the wastewater before it enters the groundwater. The depth of dry soil from the base of the drainfield to the water table (referred to as vertical separation distance) is an essential part of the treatment system, as are the horizontal distances to wells, surface waters, and drops in land slope.



Conventional septic system with septic tank and trench drainfield. The soil underlying the drainfield provides final treatment.

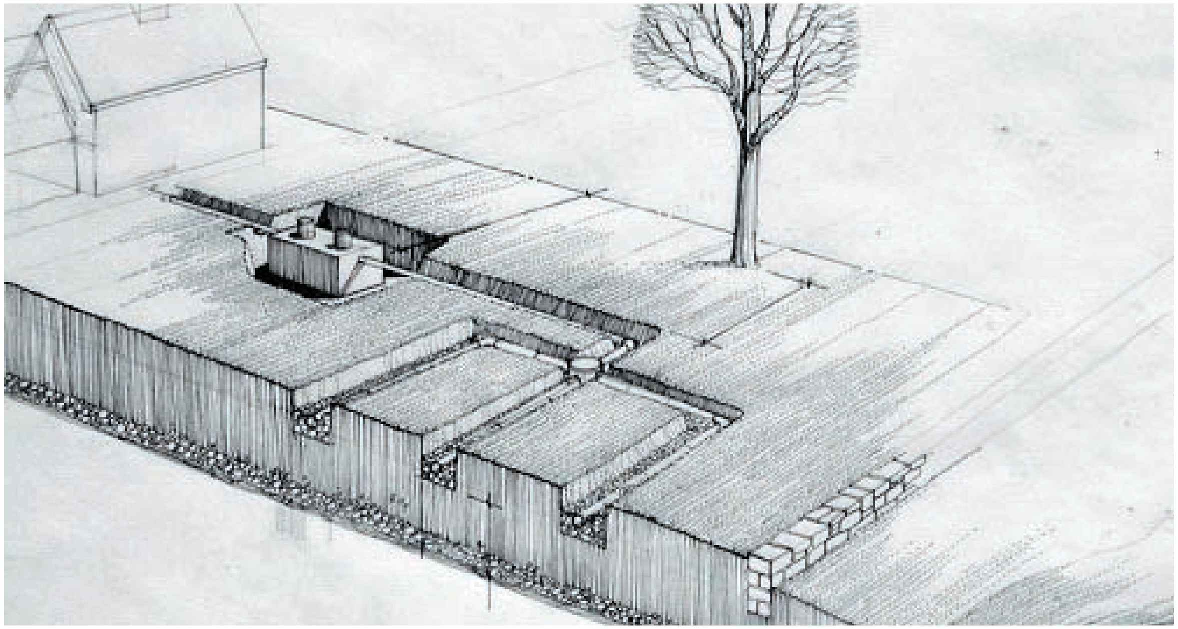
Septic Tank Facts

- Tanks are prone to leak unless properly assembled and sealed and must be tested for water tightness.
- Most tanks are concrete, but fiberglass or polyethylene may be used; they may have single or multiple compartments.
- Solids accumulate faster than they decompose, so tanks must be inspected regularly and pumped as needed, generally every 3-5 years.
- Basic improvements to tanks: effluent screens efficiently trap solids and prevent outflow to leachfield; risers (also called manholes) to the ground surface provide easy access for routine maintenance.

Drainfield Facts

- The type and size of drainfield selected for a site depends on the depth to water table, soil permeability, and available area that can be used with minimal disturbance.
- PVC pipe in stone-filled trenches is most commonly used. Other variations using synthetic material around the distribution pipe exist.
- Concrete leaching chambers are bottomless box-like or beehive-shaped structures with a network of holes for effluent seepage, commonly placed in series, and surrounded in stone. In some states, they may be used under parking lots. Deep units have small footprints, but depth of placement in sandy soils provides little treatment, and they may not be permitted in sensitive areas.

- Plastic chambers are similar to shallow concrete leaching chambers but much lighter. They may be used with or without stone.
- Prefabricated, cuspated plastic and filter fabric bundles are combined with a six-inch layer of sand to help promote more efficient treatment and, in some cases, slightly reduce drainfield size.



A conventional septic system requires a large, relatively flat area of the yard to be cleared for installation of the system; additional area is usually required for future replacement or expansion.

Photos of Tanks and Related Components

The picture above shows a concrete tank with access risers above inspection ports. When backfilled, riser lids will be at ground surface.

A double-compartment septic tank is more efficient in trapping solids than the standard single-compartment tank and may be required under local, county or state regulations. These are commonly used with advanced treatment systems, where the second compartment may double as a pump chamber.

Fiberglass and PVC tanks have the advantage of being lightweight and easy to maneuver where access for heavy equipment is limited; however, these are more susceptible to damage with improper installation or maintenance.

What Are Common Types of Drainfields?

The following typical drainfields provide a conventional level of treatment. They include deep leaching chambers (4 feet in height), shallow leaching chambers (18 inches in height), stone-filled trenches, and prefabricated plastic and filter fabric bundles.

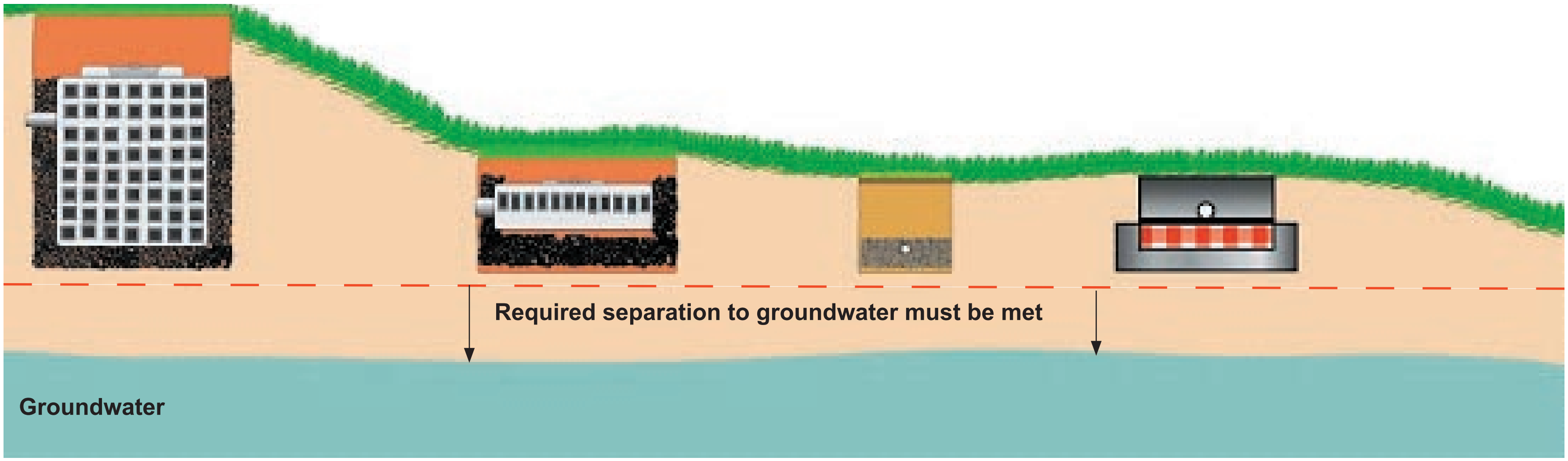
Photographs and cross sections of each of the leaching units are shown below. The diagram shows the placement of each unit relative to groundwater and ground surface. These four types are designed to be placed in deeper subsoil where pollutant removal is minimal. In some states, technologies such as plastic chambers (not shown) and the filter fabric bundle may reduce drainfield size. However, all are generally considered to provide equivalent treatment. Deep leaching chambers are not recommended in sensitive areas due to the potential for groundwater contamination.

Deep Leaching Chamber

Shallow Leaching Chamber (flow diffuser)

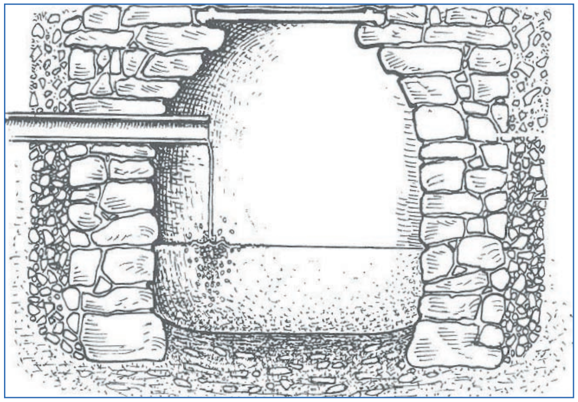
Trench

Prefabricated plastic filter fabric bundle



Cesspools and Other Substandard Systems

Cesspools are antiquated systems that receive waste from the house and allow the liquid portion to seep into the surrounding soil. The solid portion is contained in the cesspool interior. Cesspools might consist of a covered pit with loose, dry-fitted rock sidewalls, a concrete leaching chamber, or leaking steel tank. Many cesspools are in direct contact with groundwater for several months during the wet season. Because of the potential for direct, concentrated discharge of untreated waste to groundwater, cesspools are a high risk to public health and water quality. They have been prohibited for new construction for several decades, but there are many thousands of them still in use throughout the country. Some towns in Rhode Island and elsewhere have cesspool sunset or phase-out clauses in their zoning or wastewater management ordinances that would require these cesspools to be removed by certain dates.



Graphic: RI Dept. of Environmental Management

Dry fit rock cesspool being pumped. Because both solids and liquid effluent leach from cesspools, they are more likely to contaminate groundwater even where there is no obvious sign of surfacing effluent.

Nuisance algae in coastal waters outcompetes eelgrass and other beneficial aquatic plants, smothering shellfish beds and other sensitive aquatic habitat. Nitrogen, a nutrient in septic system effluent and lawn fertilizers, fuels excessive growth of algae in salt water.

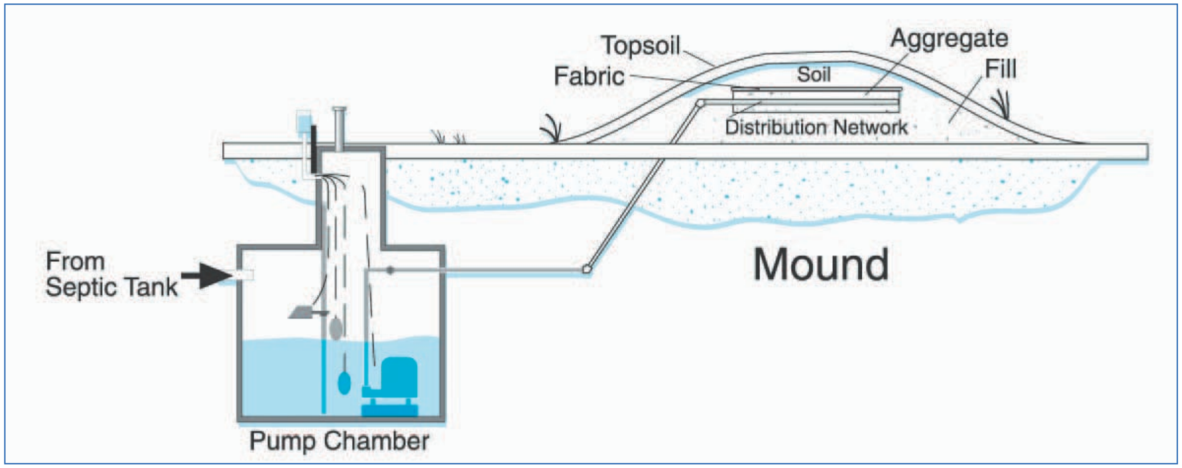
Nutrient enrichment in fresh waters can create an explosive growth of algae – an algal "bloom". In fresh water streams and ponds, phosphorus is the nutrient that stimulates nuisance growth of algae and aquatic plants. Phosphorus is found in septic system effluent, lawn fertilizers, and sediment in stormwater runoff. (Photo: URI Watershed Watch).

When faced with site constraints, system designers have devised many clever modifications to the conventional septic system. These include: raised, mounded fill systems, the Wisconsin Mound, holding tanks, and alternative toilets.

1. Raised, Mounded Fill Systems: One Answer to Site Constraints

On sites where water tables are close to the ground surface, fill systems are a standard modification to the traditional trench drainfield. Although this particular technology may be an approved method in some states, it often creates more problems than it solves. In order to meet the required separation distance on wet sites, gravel fill is typically brought in to raise the leachfield above the water table. A conventional trench, plastic chamber, or filter fabric leaching system is then placed in the fill. The same method may be used on smaller lots, where retaining walls may be required to contain the fill.

Mounds or fill systems can be 5-6 feet high, affecting the use of a property and changing the character of neighborhoods. Runoff diverted to nearby properties is often a serious problem on wet sites.



In a "mound" or "fill" system, effluent from the tank and other treatment unit is pumped to a raised leachfield constructed above the existing ground elevation. When space is available, a low, wide mound is used. When the available area is small, a high mound is needed. In general, the higher the water table, the more fill needed. This example shows a "Wisconsin mound," where the original soil below the fill is retained. Graphic: NSFC.

How Does A Fill System Work?

Wastewater enters the septic tank where solids settle and liquid effluent exits to a pump chamber. Effluent is then pumped up to the leachfield where it flows by gravity through the leaching distribution system and fill. On some new construction lots, a pump may not be needed as long as the house is elevated (often times well above the original ground surface) to provide gravity flow to the drainfield.

Siting, Design, and Treatment Issues for Fill Systems

Because the height of the mound may range from several inches to several feet above the original ground surface, raised fill systems can create areas that look out of place with a neighborhood's natural features and normal home landscapes. The mounds may drastically alter the original ground surface and natural lay of the land, destroying mature landscaping, restricting use of the lot, and altering the visual and architectural character of individual lots and whole neighborhoods.

Additionally, the raised fill often disrupts stormwater drainage patterns, creating nuisance flooding, and impairing septic system function on neighboring properties. The problem is most severe in densely developed neighborhoods and in older historic villages where even small mounds can detract from traditional architectural and natural character.

The degree of wastewater treatment in a standard fill system is about the same as a conventional onsite treatment system. With gravel fill and retaining wall construction, the cost can range from about the same to considerably more than the cost of an advanced treatment system.

This fill system, located in a historical mill village, was installed to repair an outdated cesspool. Since the gravel fill permanently blocks the shed door, the owner has lost partial use of the shed. The mature tree in the filled area is not likely to survive such treatment.

A raised fill system was used for this new private elementary school in Rhode Island (system under construction in photo, above). The expected large flows from the school, and high water table soils, required a very extensive area for the drainfield, which consumed most of an existing orchard.

The fill system used for this newly renovated house changes the look of the coastal neighborhood. The system provides only conventional treatment, without additional nitrogen removal. Zoning standards can be set to specify the level of wastewater treatment and also maximum size and lot coverage that more closely reflect traditional proportions.

Because the filled area is difficult to mow, a weed patch replaces a potential open field for recess or sports. An advanced treatment system with a shallow drainfield could have been installed level with the existing ground surface for multi-use recreation while maintaining the original look of what was once an historic farm.

The uniform, specified grain size of the sand used in a Wisconsin Mound (above) is required to enhance wastewater treatment. "Bank run" gravel (below) is often used in other fill systems. The coarse fragments and stones provide little surface area for physical or microbiological treatment in the fill type drainfield.

2. The Wisconsin Mound: An Early Advanced System

The terms "fill" and "mound" system are often used interchangeably. Although the design requirements are similar in terms of site disturbance, fill, and land area, the wastewater treatment potential is very different. A brief explanation is offered here to help eliminate any confusion. The Wisconsin Mound also uses a raised dispersal method but is engineered to provide better treatment and may be considered an alternative system. It requires about the same amount of space and site disturbance as a conventional fill system. But it provides better treatment due to three key differences: use of specified, uniform sand media as fill material; the native top soil is left in place for enhanced treatment; and the effluent is pressure- and typically time-dosed to the Wisconsin Mound surface for even distribution and therefore better treatment. With these design features, the Wisconsin Mound is more akin to a bottomless sand filter, discussed on page 19, than to the previously described raised fill systems.

3. Holding Tanks: A Last Resort

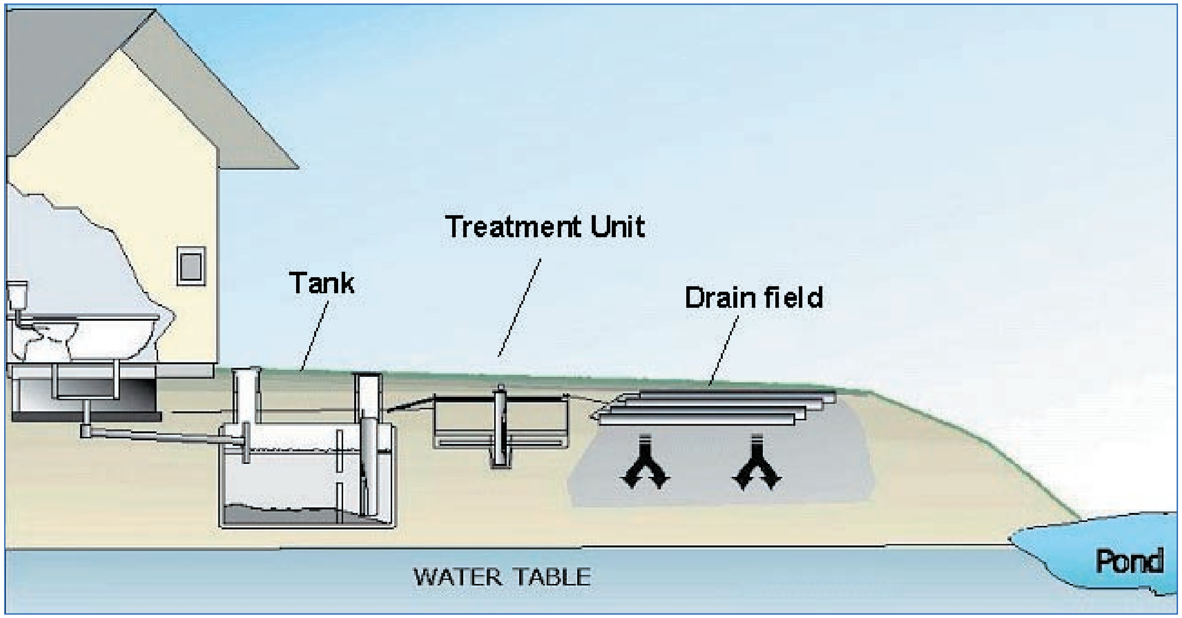
On very difficult sites, a holding tank, also called a "tight tank," may be used if permitted by local codes. As the name implies, this is simply a watertight septic tank without a drainfield. It must be pumped when full. A high water alarm may be used to indicate when pumping is needed. Some regulatory programs completely prohibit holding tanks; others typically use them as a temporary solution while a repair is completed, or as a permanent system for very difficult sites where advanced treatment systems are not permitted or are impractical.

4. Alternative Toilets

Composting and incinerating toilets are available technologies, although both require a significant amount of lifestyle adjustment. Perhaps the most common application of composting and incinerating toilets has been for seasonally-used vacation homes or cottages, where flows are typically isolated within a short period of time. Some homeowners prefer composting toilets, although they require active management of the composting process, and this may be beyond the level of involvement that most homeowners expect to devote to their system. Another factor to consider is that composting toilets are difficult to retrofit and are more suitable for new construction. Both of these systems treat only the black water (feces and urine) component of the waste stream. In each case, a separate gray water septic system is needed to treat the other wastewater, increasing costs and making these options less attractive for many homeowners.

Alternative and innovative systems, also referred to as advanced treatment systems, are general terms for any wastewater treatment system that is different from the conventional model. This encompasses a broad range of technologies that vary widely in treatment performance and space requirements. These terms may refer to a complete treatment system or just one component within a system.

The unique feature that sets alternative treatment systems apart is that a separate treatment unit located after the septic tank actually treats the effluent before it is discharged to the drainfield. The septic tank and drainfield perform the same functions that they do in a conventional system; it is the additional treatment step that enables advanced treatment systems to achieve consistently high results. **This arrangement of treatment components in sequence is referred to as a "treatment train."**



Alternative and innovative systems add a component between the septic tank and drainfield.

Why Use Alternative and Innovative Systems?

Site Constraints

Conventional systems often will not physically fit on new lots or on existing lots that have failed systems and very limited space. This makes an alternative system, which allows more flexibility in drainfield siting, an attractive option for many homeowners. In addition, some regulatory programs recognize the higher levels of treatment achieved with alternative systems and consequently allow drainfield sizes to be slightly reduced. In high water tables, where a raised fill system would typically be required, advanced treatment systems can be used to avoid the impacts of fill systems, preserve the natural and architectural character of the area, and protect water quality more effectively.

Cost Effectiveness

While the installation, operation, and maintenance costs may be higher than those associated with conventional systems, advanced systems may be the only option that allows full use and enjoyment of the property. Therefore, as site constraints increase, alternative and innovative systems become more cost effective and sometimes even less costly than conventional systems. In addition, advanced systems using alternative drainfields avoid the significant and costly land disturbances required by fill systems; and they allow mature landscapes and plantings to remain intact, often a significant time and monetary savings. It is important to note, however, that where a conventional drainfield is used, or under regulatory programs where drainfield size reductions are not allowed, economic and space benefits may not be realized.

Ecologically Sensitive Areas

Since conventional systems are not designed to remove nitrogen, advanced treatment systems may be required in nitrogen-sensitive coastal waters. Additionally, advanced treatment may be needed to protect groundwater resources or phosphorus-sensitive freshwaters. Advanced systems also can be used to protect nearby wells and surface waters from bacterial contaminants.

Consistent Treatment Performance

Alternative systems employ one or more treatment units that help achieve consistent pollutant removal, although the reliability of this performance largely depends upon required operation, maintenance, and management. Some systems are specially designed to reduce nitrogen and can remove at least 50 percent of the nitrogen being discharged from the home. Additionally, the use of alternative drainfields can achieve effective phosphorus removal.

What Tank Features Are Common in Advanced Treatment Systems?

- **Watertight tanks**, which are generally required by most regulatory codes, are important for all systems, but they are absolutely essential with alternative and innovative systems.
- **Concrete and fiberglass septic tanks** generally are used for advanced treatment systems. Polyethylene septic tanks may be used, if structural issues are addressed.
- **Two-compartment tanks** are often used. These tanks typically have a pump in a protective screen vault, which filters wastewater before it is pumped to the advanced treatment unit.
- **Pumps** may be used as needed, located either within the septic tank or in a separate pump chamber.
- **Flow equalization tanks** may be used for shared or large systems. These are tanks that accept and store effluent following the septic tank and before the treatment unit. They help to moderate peak flows and provide a way to collect flow from different sources before treatment.
- **Peak flow modulation** is typically achieved by designing a 150 to 300 gallon reserve capacity in the head space of the septic tank to capture and temporarily store large surges of water from the building. This assures minimal damage to the system and consistent treatment.

Important Notes About Maintenance

All wastewater treatment systems require operation and maintenance to assure system longevity, although the degree of operation and maintenance varies between systems. Without a doubt, alternative systems require more attention than conventional systems.

However, the operation and maintenance associated with alternative systems is often perceived to be more time consuming than it actually is. This can be attributed largely to the fact that many conventional onsite wastewater system users are accustomed to doing nothing to their systems.

It is important to compare the level of *proper* maintenance for a conventional system to the level of maintenance required by an alternative system. Conventional systems generally require tank inspections and pump outs at least every three to five years; alternative systems also require inspection and maintenance of the treatment unit at least once a year. Because alternative treatment systems will fail without routine maintenance, it is critical that a community wastewater management program or other management entity be established to oversee and ensure proper maintenance wherever alternative systems are used.

Concrete Septic Tank. Large capacity tank showing seam where tank was assembled. Testing for watertightness ensures seams are properly sealed.

A pump chamber. This may also house recirculating valves, timers and other controls. The finished unit will have a green lid at the ground surface.

Inspection is a fundamental part of maintenance. This device measures scum and sludge depth in the septic tank.

What Makes Advanced Treatment Systems Unique?

Design

- They utilize a treatment train design with at least one treatment unit after the tank and before the drainfield.
- A treatment unit is selected based upon proven treatment performance that incorporates site constraints and resource protection goals.
- Tanks have effluent screens, access risers, and are tested for watertightness.
- Small, highly reliable pumps are used to distribute waste on a scheduled basis to the treatment unit and drainfield without relying on gravity flow.
- Alternative drainfields may be used and are designed to fit around existing landscaping and buildings, causing minimal site disturbance.
- They can use modular, prepacked components, optimizing quality control, promoting ease of installation, and reducing installation cost.
- They can use synthetic and absorbent, porous media, reducing the need for specified sand media and lowering transportation costs.

Performance

- Tanks achieve enhanced primary treatment, using a larger tank to store peak flows.
- Treatment units placed after the septic tank and before the drainfield achieve secondary treatment.
- They achieve better water distribution to the drainfield by timed, small, frequent pressure dosing rather than gravity flow by demand.
- They achieve enhanced, additional treatment in drainfields using shallow drainfields or bottomless sand filters.

Installation and Maintenance

- Installation can be completed using small, lightweight, earth-moving equipment in tight areas with limited site disturbance.
- The system function can be monitored remotely by computer, through the use of remote telemetry.
- Alarms signal potential problems.

What Components Are Used in Advanced Treatment Systems?

A variety of units could be used in a treatment train to maximize the removal of particular contaminants in the waste stream. The type of treatment unit selected depends upon the contaminant to be removed and the level of removal desired. The treatment units discussed in the following sections include media filters, aerobic systems, and special-use alternatives such as ultraviolet light disinfection units and alternative drainfields.

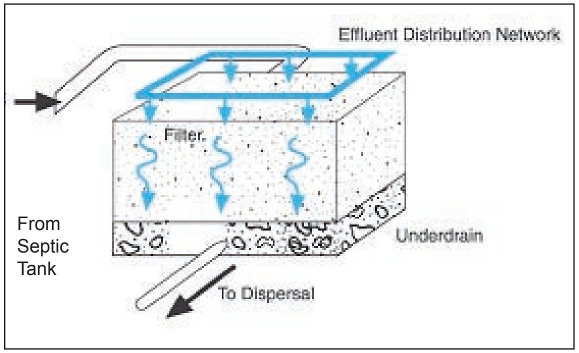
1. Media Filters

Media filters consist of a lined or watertight structure filled with media that treat wastewater using physical and biological processes. The general treatment train collects effluent in a septic tank, pumps it to the top of the filter, and distributes it over the media surface. Regardless of the filter type, the media provides surface area for bacteria and other microorganisms, which are responsible for treating the wastewater. The filter bed is never saturated with water, and the presence of air promotes the establishment of favorable microorganisms.

Most media filters use a programmable timer to dose small and uniform amounts of wastewater to the filter surface. Some media filter designs do not employ time dosing, preferring to apply wastewater to the filter surface by either gravity or pressure dosing using preset float switches. Storing peak flows and timing doses of wastewater helps minimize filter overload and keeps the system working on a twenty-four basis to treat stored wastewater.

A) Single Pass Filters Vs. Recirculating Filters

The oldest type of media filter bed, long serving as the industry standard, is the single pass sand filter which has been used for both water and wastewater treatment for over 100 years. Although generally not regarded as a nitrogen reduction system, single pass sand filters are a proven technology for reducing pathogenic organisms. **In single pass systems, the treated effluent is collected at the bottom of the filter bed and usually dosed to the drainfield for final treatment and dispersal.** Single pass filters generally excel in pathogen removal.



Single pass filter. Graphic: NSFC.

In recirculating filters, the partially treated effluent trickles down through the media, is collected in the bottom of the filter, and recirculates between the tank and the media filter several times before final discharge to the drainfield. This recirculation process, a combination of aerobic treatment in the media filter and anaerobic conditions in the tank, are required steps to convert dissolved nitrogen to N_2 gas. Recirculating sand filters have been used successfully for several decades and are widely accepted as an onsite nitrogen reduction technology. In some states, certain single pass filters are approved for pathogen sensitive areas and certain recirculating media filters are approved for nitrogen reduction. County or state regulators can provide information as to which media filters are approved for specific applications.

Installing a sand filter.

B) Sand Vs. Alternative Media

Regional variations to the single pass sand filter have used other solid granular media such as crushed glass and bottom ash (a byproduct of coal fired power plants). The use of glass media was isolated to northwestern United States and western Canada and is used on a limited basis today, whereas the use of bottom ash is still used in some Appalachian Mountain states where coal fired power plants are common.

In recent years, alternative media have been substituted for the non-absorbent granular media (such as sand) mentioned above to encourage more efficient movement of wastewater and gases in the filter bed. This promotes better treatment performance and helps to reduce the system footprint so that it can fit into tight areas. The absorbent media filters used in a single pass mode include peat and open cell foam. Textile media, another more recent absorbent media, is used in recirculating filters.

Alternative Media:
Foam (top), Peat (middle), and textile (bottom) filters.

C) Advantages of Specific Media

The use of alternate and more readily available media helps address the issues often associated with sand or any other granular material. These issues include the availability of good quality media, cost of transport, quality control during installation, and cost of installation. Generally, modular, prefabricated and prepackaged media filters such as peat, foam, and textile systems have advantages over other media filters that must be constructed entirely on site. Those advantages include easier transport, quicker installation, and higher installation quality control, all of which should produce more affordable systems. The challenge, however, for these newer filters is trying to match the long-term treatment performance, low levels of operation and maintenance, and general robustness of sand filters.

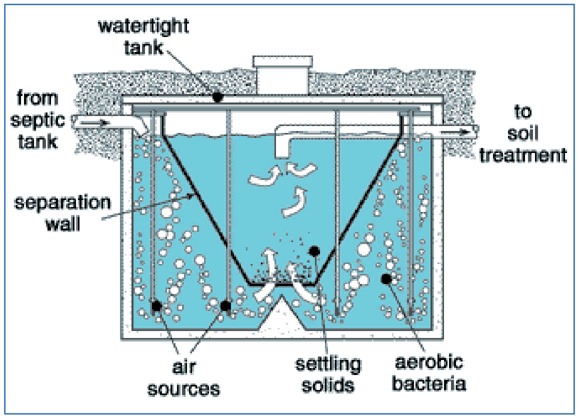
2. Aerobic Treatment Units

Aerobic treatment units (ATUs) rely on air injection systems and blowers to create an oxygenated (aerobic) environment, which aids bacteria as they break down organic material. This aeration process produces an effluent that compared to a conventional system, is lower in total suspended solids (TSS) and biochemical oxygen demand (BOD) and has some reduction in bacteria. The injection of air into the ATU agitates the wastewater, so solids are mixed with the bacteria that digest organic material. Usually there is a step in the process where any settled solids and bacteria are returned back to the aerobic portion of the tank for mixing and additional treatment, and it is common for there to be at least one additional stage in the treatment process that allows solids and bacteria to settle out of the wastewater so that cleaner wastewater is distributed to the drainfield.

There are three basic operating modes for ATUs: suspended-growth, fixed-film reactor, and sequencing batch reactor. All three types have a solids (trash) removal step as the first process in their treatment trains, so that large solids do not inhibit the aeration process. The differences in the three types of operating modes are discussed in the following sections.

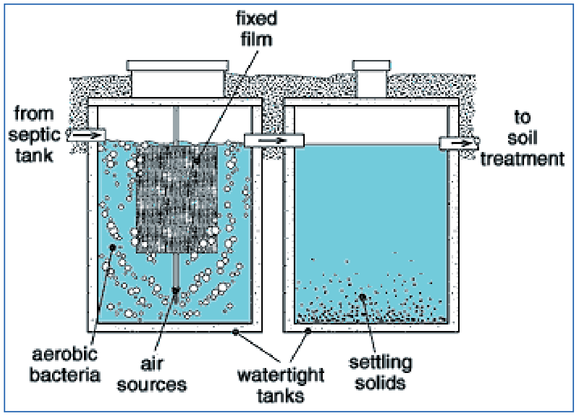
A) Suspended Growth

In the suspended-growth ATU, bacteria are free floating (suspended by the aeration process) in the main chamber. The last chamber is the zone where solids and bacteria settle out and are returned back to the aeration chamber by either a port on the bottom or by a recirculation pump. Proper aeration, mixing, and return are critical for adequate operation and treatment. Clarified, treated wastewater from this chamber is piped to the drainfield.



A suspended growth aerobic treatment unit. Graphic: NSFC.

This type of ATU is prone to bulking problems, where clumps of bacteria and some solids don't settle to the bottom of the unit and tend to clog the outflow pipe to the drainfield. While the suspended growth ATU reduces BOD and TSS, it does not result in levels low enough to permit the use of alternative drainfields, nor does it reduce nitrogen or bacteria. The additional cost of this system, as well as its annual maintenance requirement, should be compared to other advanced treatment systems that may provide greater environmental benefits.



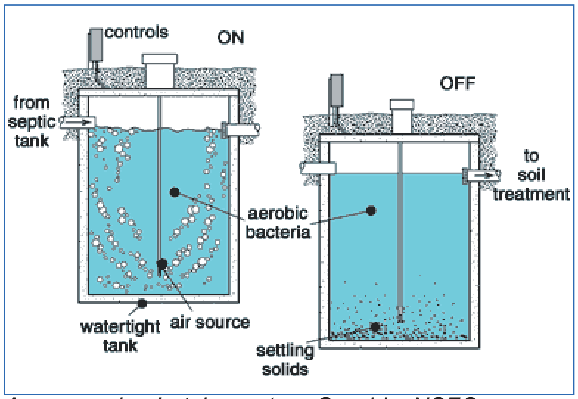
A fixed-film reactor. Graphic: NSFC.

B) Fixed-Film Reactor

A fixed-film reactor has bacteria growing on a surface medium suspended in the tank where the air is injected. The medium that the bacteria grow on can be made of a variety of materials including plastic, fabric, styrofoam, or gravel. Organic matter decomposes in this chamber, and a separate chamber is used for settling and clarification. Treated wastewater flows from the settling chamber to the drainfield for final dispersal. Fixed-film reactors usually don't produce bulking or require a return mechanism, but they tend to be more expensive than suspended-growth systems.

C) Sequencing Batch Reactor

In a sequencing batch reactor (SBR), filling, aerobic decomposition, settling, return, and discharge processes all take place in a single chamber or basin and occur in one complete cycle. During the filling step, incoming wastewater mixes with sludge remaining from the previous cycle. Air is injected into the wastewater and mixed during the decomposition cycle. After the settling stage the treated wastewater is discharged to the drainfield. This process tends to be more consistent, but since it has more moving parts it has a higher potential for mechanical, electrical, or operational failure and requires more frequent



A sequencing batch reactor. Graphic: NSFC.

maintenance checks. Although this type may be used for individual onsite systems, this process is more commonly used for large-flow cluster systems.

D) Advantages and Disadvantages of ATUs

Some fixed-film and sequencing batch reactor ATUs are approved for nitrogen and phosphorus reduction, whereas others, including the suspended-growth varieties, are used to reduce TSS and BOD levels. The cleaner wastewater and reduction in TSS, BOD, and bacteria are regarded as the primary advantages of ATUs over conventional systems. In some states, drainfield size reductions or vertical separation distance benefits also may be awarded for using a particular type of ATU. Because the treatment unit can be located within the septic tank, most ATUs have fairly small footprints and thus have the advantage of fitting in tight spaces. In addition, ATUs generally have a somewhat lower initial capital cost than other technologies.

However, the operation and maintenance costs of ATUs tend to be higher than other technologies, especially where electricity costs are high. This is due to the fact that the blower motors must run continuously. In addition to the cost to operate them, noise from blower motors may be an issue for some homeowners or neighbors to consider. ATUs that do not incorporate time dosing in their treatment trains will not be able to store peak surge flows from a building. Due to the increased number of mechanical parts compared to those required by filters, ATUs pose an inherently higher risk of treatment failure and drainfield clogging or overloading.

3. Ultraviolet Light Disinfection Unit

The treatment train approach to system design is flexible, allowing additional components to be added as needed. One unit, now being used more commonly when separation distances to wells are inadequate, is the ultraviolet light disinfection (UV) unit. This is normally included in a pump chamber, following treatment and prior to final discharge to the leachfield.

UV units have proven effective in eliminating bacteria. A high level of BOD and TSS removal is required however, before a UV unit can be included as a component of a system. In addition to regular maintenance and replacement of UV lamps as needed, an adequate alarm system needs to be employed to safeguard against lamp outages or power interruptions.

4. Alternative Drainfields

Alternative drainfields used with innovative technologies will fit into the landscape, treat wastewater far more effectively, and will last longer than a conventional drainfield. There are two drainfield options typically used which are both pressure dosed for uniform wastewater distribution: shallow pressurized drainfields and bottomless sand filters. Both of these alternative drainfields substitute for the raised gravel fill system discussed earlier, providing much better treatment with minimal site disturbance. The typical separation distances to boulders, land slopes, and trees and shrubs that apply to conventional drainfields are usually relaxed somewhat with these options, providing greater flexibility in siting.

Shallow narrow drainfield following a recirculating media filter. The drainfield is visible as the area with greener lawn, also showing additional nutrient uptake by plants. In this area, the drainfield helps protect local drinking water wells and coastal pond water quality.

A) Shallow Narrow Pressurized Drainfields

Shallow narrow pressurized drainfields, which are placed in the upper soil layers for maximum wastewater treatment by natural soil processes, are located about 8-12 inches from the ground surface. They can be used when the water table is at least 3'-10" from the ground surface. Shallow narrow pressurized drainfields (a variant of low pressure pipe type drainfields) are used in many regions of the United States.

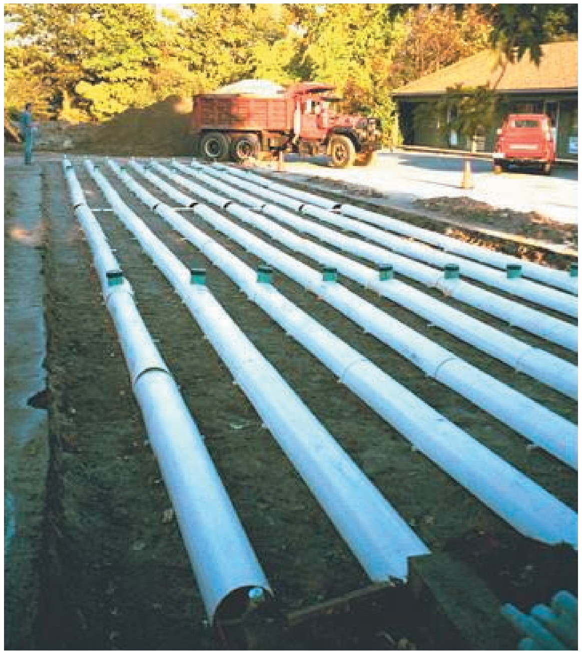
B) Drip Distribution

Another type of alternative drainfield is the subsurface drip distribution system. This system uses small diameter lines to disperse and recycle pretreated wastewater just beneath the ground surface. Often, the drip distribution lines are located in a lawn or other landscaped area to maximize wastewater reuse for irrigation.

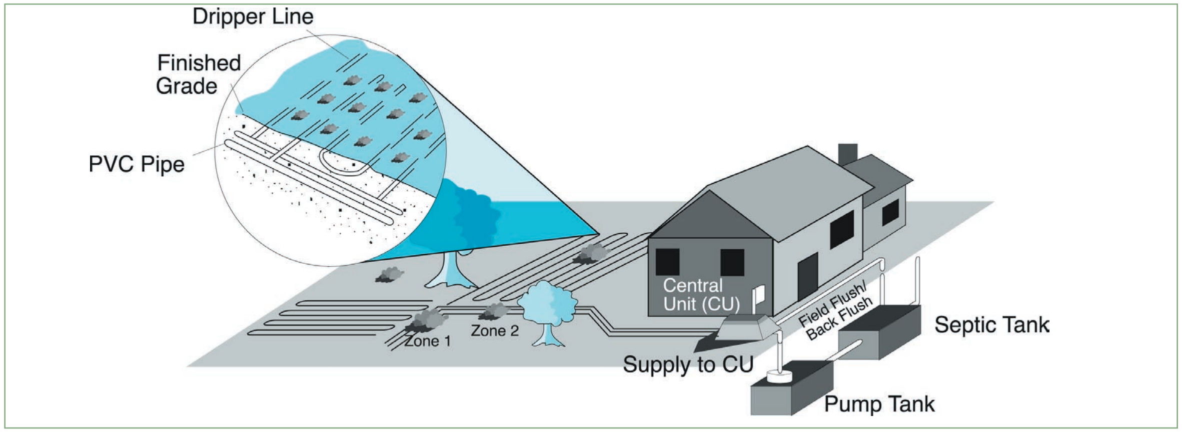
The treatment train for a drip irrigation system consists of a septic tank, one or more treatment units, and a pump tank. Treated wastewater is pressure dosed to the drip distribution lines, which function as the final drainfield. To prevent clogging of the irrigation lines, wastewater must be treated to remove fine particles. A disc filter is commonly used, either immediately after the tank or following a treatment unit capable of high BOD and TSS removal. The specific treatment device used depends upon the type of drip tubing and the manufacturer's recommendations.

The drip distribution system is made of tubing that is generally 0.5 inches in diameter, installed 6 to 10 inches below the soil surface (or deeper to prevent freezing in cold climates). Drip outlets, known as emitters, are placed at regular intervals within the tubing wall. The pressure inside the

Installation of a shallow, narrow drainfield. Pressurized laterals (1" diameter PVC pipes) are shielded with 12" PVC pipe cut lengthwise, with at-grade inspection ports located at regular intervals. Shallow narrow drainfields take advantage of biochemically-active upper soil layers for microbial nutrient removal and plant uptake.



A shallow, narrow drainfield showing the outer PVC pipes that cover the pressure laterals. This drainfield serves a 2700 gallon-per-day restaurant and retail / office complex. These lines, located in a parking lot island, are ready to be covered with native backfill, and will be 12" below finish grade.



A typical drip distribution system. Like all advanced treatment systems, it requires regular maintenance to function properly. Without proper maintenance, the drip emitters can become clogged with organic material. Graphic: NSFC.

tubing is typically 15 to 20 pounds per square inch (psi), and the water exits the emitters at 0 psi. The distribution system is placed into the undisturbed soil without any specific media surrounding the distribution lines. This maximizes natural pollutant removal in soil and reduces the need for site disturbance. Specific depths of unsaturated soil are required below the drip lines to provide sufficient treatment.

Drip irrigation has been widely used for both individual residential septic systems and large cluster systems. Drip irrigation is beneficial where lawns or other landscaped areas are available, especially where water conservation and reuse is critical.

C) Bottomless Sand Filters

Bottomless sand filters have been used to treat raw septic tank effluent in several west coast states with good success. In Rhode Island, **bottomless sand filters provide a raised bed for final wastewater treatment and dispersal of advanced treated effluent.** These are easily installed with little site disturbance, and they maximize separation distance to groundwater. As a result, they are often ideal for repairs where water tables are near the surface and where small lot size restricts other options.

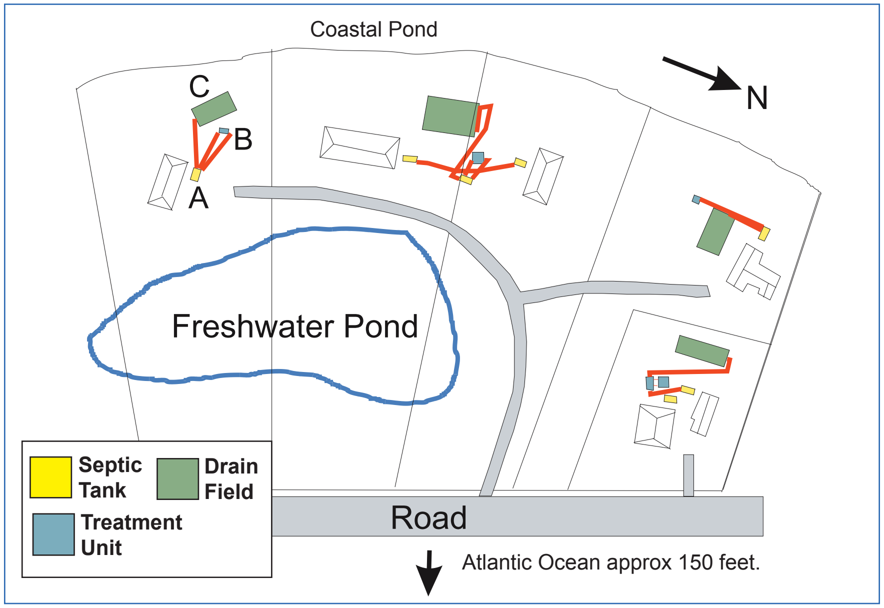
An ultraviolet light disinfection unit further reduces bacteria following the treatment unit. It typically fits into the pump chamber where treated effluent is pressure dosed to the drainfield for final dispersal.

Raised bottomless sand filters, following a recirculating media filter. The system shown below serves a single-family home, and was installed as a repair to a failed cesspool. The system on top left serves a multifamily and commercial property in a village center. The distribution lines will be covered with gravel.

Important Notes About Alternative Technology Combinations

In some cases, conventional gravity-fed drainfields are used with advanced treatment. Not only does this choice of drainfield cause more site disturbance, but also it presents a water quality concern. With this combination of technologies, highly treated wastewater is likely to leach quickly through the soil without build-up of a microbial biomat to slow effluent for better treatment. As a result, rapid infiltration over a small area can increase the risk of groundwater contamination locally. It is necessary to mix and match alternative technologies in a treatment train to achieve a desired treatment level. However, the technologies must compliment the choice of components that may come before and after.

The previous chapters in this manual offer information about treatment systems, with an individual property owner in mind. However, advanced treatment systems can also be sized to treat waste from clusters of two or three homes or even an entire neighborhood, while still using a soil-based leaching system for final treatment and dispersal. This chapter offers information about treatment system options for large flow systems, and it discusses collection system options that transfer wastewater to a treatment unit from more than one property.



A Block Island residential compound with a combination of individual and shared systems. The diagram illustrates how wastewater from the homes flows into a septic tank (A) where effluent is recirculated to a media filter (B). Final treated effluent is dispersed to a shallow narrow drainfield (C). As the diagram shows, four alternative systems handle flow from the six buildings in this compound.

A Review of Rhode Island Large Flow Systems

A review of local and county approvals for cluster systems can provide insight into the approved systems most commonly used and presumably cost effective for a particular area. A review of the Rhode Island Department of Environmental Management (RIDEM) wastewater permit applications for large-flow alternative treatment systems (design flow of 1,000 gallons per day or greater) for the period 1995 through 2003, indicates that **media filters and fixed activated sludge units are most commonly used for systems in the 1,000 to 5,000 gallon per day range.**

These smaller systems comprise 67% of all large flow alternative wastewater treatment system permits issued for this period. They are commonly paired with alternative drainfields, using either shallow trench designs or bottomless sand filters for final wastewater treatment and dispersal. **In the 10,000 to 40,000 gallon-per-day range, RIDEM applications show that recirculating sand filters and self-contained treatment units are commonly used, including fixed activated sludge systems, trickling filters, sequencing batch reactors, and rotating biological contactors.** At larger flows, a variety of alternative or conventional soil-based leaching systems may be used, including pressurized shallow trenches, conventional drainfield trenches and flow diffusers.

The maximum size cluster system installed in Rhode Island has been in the 40,000 gallon-per-day range. Elsewhere in New England, cluster systems of 20,000 to 80,000 gallons per day are more common, with a few approaching 200,000 gallons per day (personal communication, Keith, Dobie, F.R. Mahoney & Associates). **At flows of 100,000 to 200,000 gallons per day and greater, advanced treatment systems supporting water reuse and recycling may become feasible.** Several commercial centers, resorts, and stadium complexes have been built in New England taking advantage of membrane systems to generate very high quality wastewater that is stored and reused internally for toilet flushing, thereby reducing both water demand and wastewater leachfield requirements. Although recycling systems have been used more extensively in arid areas, summer water shortages and growth pressures with growing demands for clean water are making reuse and recycling systems increasingly cost effective even in the humid northeast.

Treatment Systems

Large flow systems using advanced treatment systems can achieve high levels of treatment and recycle effluent to the same watersheds, thereby replenishing groundwater supplies and maintaining stream flows. In contrast, most conventional centralized collection and treatment systems typically discharge directly to surface waters without these benefits, often transferring wastewater to a downstream subwatershed or an entirely different basin than the original source of the water supply. As with any soil-based leaching system, attention must be paid to careful site evaluation and soil suitability, when using onsite leaching systems for large flow cluster systems.

The wastewater treatment technologies discussed in previous chapters can be sized up, often using zones that can be phased in over time and incorporating modular treatment units to accommodate larger flows. **In general, at flows of 10,000 to 50,000 gallons per day, large recirculating sand filters and modular technologies may still be used, but pre-fabricated mechanical treatment units, called "package plants," may also become cost effective** (H R Consultants, 1998; University of Minnesota Extension Service, 1998). Examples of pre-fabricated units available from various manufacturers include:

- fixed activated sludge treatment systems,
- trickling filters,
- rotating biological contactors,
- sequencing batch reactors, and
- membrane filtration systems.

Selecting a Treatment System for a Large Flow Cluster System

Selection of a treatment system is highly specific to the site, although the key factors to consider include:

- development density,
- treatment level needed to protect local resources and overcome site constraints,
- land area and siting constraints, and
- overall life cycle cost considering both construction and long-term maintenance.

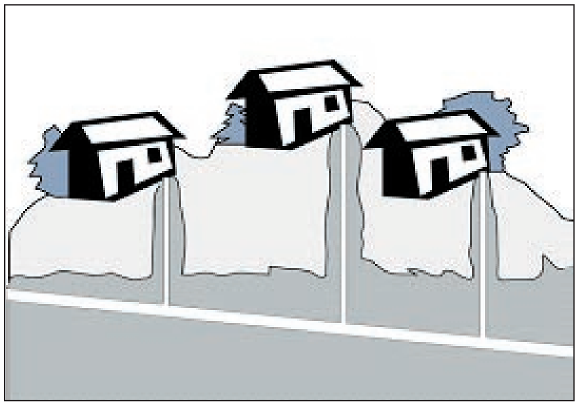
Engineered treatment units can be specifically designed to treat certain types of contaminants such as BOD, grease, and nutrients. Treatment technologies such as membrane filtration systems are capable of reducing nitrogen to levels as low as 2-3 milligrams per liter. Site design considerations also come into play in selecting the appropriate type to meet specific challenges. For example, some treatment units such as rotating biological contactors are typically housed in a garage or barn. Others, such as the sequencing batch reactor, can be located underground using very little space but requiring deep excavation. Treatment technologies also may be tailored to the level and strength of the effluent flow. For example, restaurants typically have high flow with high strength, which requires special maintenance to keep the system functioning over the long term.

Collection Systems

Collection systems serve a different function than treatment systems. They are a method for collecting and transferring wastewater to a treatment unit from one or more discharge locations. The three collection systems discussed in this section range from the most conventional to the most innovative and include the gravity sewer, grinder pump pressure collection, and septic tank gravity and pressure collection.

1. Gravity Sewer: The Conventional Approach

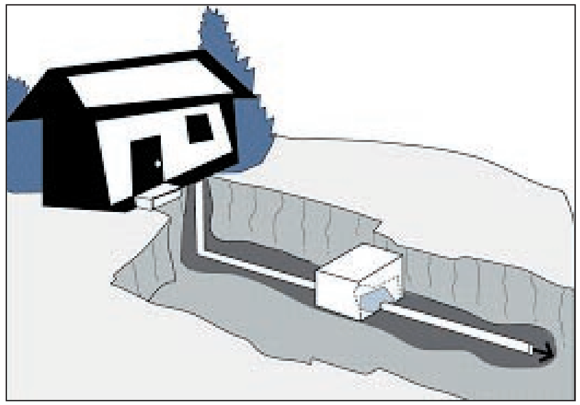
The conventional wastewater collection method used by most sewered communities is a network of large diameter pipes using gravity flow. Excavation costs are high because of the size of the lines, the great depth often needed to maintain gravity flow, and the necessity of placing manholes at regular intervals. Pump stations are used at intervals to pump up to a higher point where needed. Sewer lines are prone to leakage and must be maintained and sealed as needed. Groundwater infiltration is often a greater concern than effluent leakage from the pipe. Groundwater flowing into cracked or poorly sealed pipes diverts groundwater to the treatment plant, using up valuable capacity. Just as importantly, groundwater diversion lowers water tables and can seriously impair stream habitat and water quality. According to EPA (1997), wastewater collection and treatment using conventional gravity sewers is generally more cost effective when lines are concentrated about 100 houses per mile, where a good business and industrial base exists, and where the distance to a main sewer line is within 5 miles.



Gravity Sewer.

2. Grinder Pump Pressure Collection: A Bridge Between Convention and Innovation

With pressure collection, small-diameter pressurized lines are used to convey wastewater to a central treatment facility. The lines generally follow topography, eliminating the need for deep excavation to maintain gravity flow. Instead of a septic tank, each house would have a tank housing a grinder pump. When the tank fills, the pump grinds the waste into a slurry which is discharged to the pressure line. Because grinding solids tends to wear out components, grinder pumps generally have higher maintenance needs than effluent pumps. Larger prefabricated “package” treatment units, such as those described above, often use this method rather than separating solids with a septic tank at each site. Where large flows include high-strength commercial waste, blending wastewater flows from various sources can keep overall waste strength low, improving treatment efficiency. Because solids are not retained in a septic tank, treatment units using this method will generate relatively large amounts of sludge, which must be separated, dewatered, and disposed of regularly.

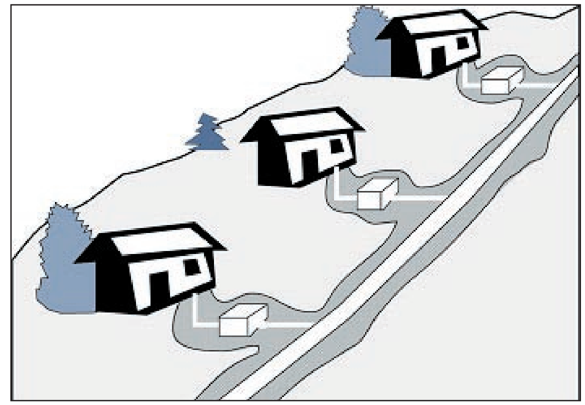


Grinder Pump.

3. Septic Tank Effluent Gravity (STEG) and Pressure (STEP) Collection: The Innovative Approach

Septic tank effluent gravity (STEG) tanks trap and retain solids at the point of discharge and transfer, by gravity flow, relatively clear effluent to the next treatment stage. STEP (septic tank effluent pump) tanks are similar, but instead pump the effluent because the treatment unit may be at a different elevation where gravity is not feasible. Both of these methods are highly innovative in that they move only relatively clear effluent and keep solids in tanks for additional decomposition and processing. They are typically used with smaller shared systems.

Effluent pumps, which are similar to those used for drilled wells, tend to have fairly low maintenance needs compared to grinder pumps. This on-lot solids decomposition reduces the total amount of organic material that ultimately needs to be processed at the wastewater treatment unit. With small cluster systems, segregating flows using individual tanks provides better control in pretreating waste and solids removal, often at lower energy cost. This means that responsible septage management and the inconvenience of



Septic Tank Effluent Collection. Graphics: NSFC.

individual tank pumping will need to be shouldered by the homeowner or a responsible management party. Depending on the flow, more than one building could be connected to the same STEG / STEP tank, and these tanks can flow to a variety of treatment options, ranging from conventional to advanced technologies. These collection systems are commonly used with cluster or larger systems, because they save space and are a cost effective means to move wastewater from one point on the landscape to another. According to the University of Minnesota Extension Service (1998), cluster systems served by STEP / STEG collection systems tend to become more cost effective than individual systems where flows range from 5,000 to 15,000 gallons per day.

For the uninitiated, choosing the most appropriate treatment system can be a mind-boggling chore. Usually, watershed-level and individual site-level factors need to be assessed before a decision is made. The watershed-level factors, such as watershed susceptibility to nitrogen or pathogen inputs are abstract concepts to many people, even system designers. Until fairly recently, not many regulatory programs nationwide had established watershed treatment zones or standards that needed to be met. As a result, the watershed-level system selection factors, which really are the first decision step, may not be well understood by some wastewater professionals in various locations across the county. The individual site-level factors are all the normal site-specific characteristics that the design professional determines and assembles into a permit package that is sent to regulatory review.

The following check-list is intended to provide some guidance with both watershed-level and individual site-level considerations. While the following information is not comprehensive, it does offer a fundamental reference to help with treatment system selection.

System Design

- ☐ Ease of installation for new or repair system
- ☐ Maintenance frequency
- ☐ Component longevity
- ☐ Overall system reliability

Site Suitability

- ☐ Depth to water table or other limiting layers
- ☐ Potential for water table rise
- ☐ Soil permeability
- ☐ Location with setbacks from wetlands and surface waters
- ☐ Proximity to public and private wells
- ☐ Proximity to shoreline areas
- ☐ Adequate space to repair a failing system
- ☐ Adequate space for alternate drainfields
- ☐ Ease of access for routine maintenance by inspector or pump trucks
- ☐ Existing obstacles such as boulders, sheds, gardens, or swing sets
- ☐ Potential or existing drainage patterns

Aesthetic Concerns

- ☐ Site alteration requirements such as excavation or filling
- ☐ If filling is required, height of the fill and slope
- ☐ If a retaining wall is used, landscaping decisions
- ☐ Landscaping removal or damage
- ☐ Full use and enjoyment of property
- ☐ Appearance on lot and within neighborhood

Waste Type, Strength, and Quantity

- ☐ Multifamily home with multiple kitchens
- ☐ Commercial or business property
- ☐ Seasonal or rental property
- ☐ High flow or variable flow

Excavation for Collection Lines

- ☐ Ledge requiring blasting
- ☐ Shallow water table requiring de-water trench, restricting construction during seasonal high water table, or restricting construction during high tide if located in a coastal area
- ☐ Favorable grades from homes to dispersal sites
- ☐ Need for wetland permit in some areas

Working With System Designers and Installers

Septic system designers and installers are often more comfortable with the technologies that are familiar to them than with some of the alternative and innovative technologies described in this manual. When choosing the wastewater treatment system that is best for your property, be sure to get more than one estimate. And when working with system designers, be sure to ask them to explain why their recommended system is the most appropriate for your needs.

Estimated Treatment Costs Per Residence [1]			
Treatment Option	**Design and Installation**	**Annual Opera-tion**	**Total Cost***
Conventional System [2]	$5,000 - $8,000	$100 - $200	$7,000 - $12,000
Mound or fill system with minor filling	$7,000 - $12,000	$100 - $400	$9,000 - $20,000
Mound or fill system on dif-ficult site	up to $30,000	$100 - $400	$20,000 - $38,000
Aerobic Tank	$8,000 - $15,000	$500 - $800	$25,000 - $30,000
Single Pass Sand Filter with shallow drainfield [3]	$8,000 - $20,000	$200 - $500	$22,000 - $24,000
Fixed Activated Sludge system [3]	$15,000 - $25,000	$600 - $800	$22,000 - $36,000
Peat Filter with Shallow Drain-field [3]	$15,000 - $24,000	$300 - $500	$22,000 - $27,000
Recirculating Media Filter with Shallow Drainfield [3]	$18,000- $21,000	$300 - $400	$25,000 - $28,000
Ultraviolet Light	<$1,000	$135	$3,700

*Assuming a 20-year time period and average design, installation and opera-tion costs. Costs may be more or less based on location. Does not take into account interest or other financing expenses.

1. Costs are highly site specific and vary nationally. Estimates are based primarily on Northeast and Great Lakes regions.

2. Unless specified, includes a trench or other conventional drainfield.

3. Drainfield is shallow, narrow pressure-dosed alternative design.

Sources: University of Minnesota Extension Service and College of Agricultural, Food and Environ-mental Sciences. Innovative Onsite Sewage Treatment Systems. University of Minnesota, 2001.

University of Rhode Island Cooperative Extension. 2003. Alternative and Innovative System Matrix Review. Onsite Wastewater Training Center. www.uri.edu/ce/wq Kingston, RI

Environmental Protection Agency. Onsite Wastewater Treatment Systems Manual, Table 5-8, Sec-tion 5-31. February, 2002.

Cost Considerations

Certainly one of the most significant factors to consider is system cost. The costs that need to be considered before a system is selected include:

- ☐ Design costs,
- ☐ Installation costs,
- ☐ Operation costs, and
- ☐ Maintenance costs.

It is important to remember that some technologies may have a lower initial capital cost, making them attractive from that perspective, but they may have much higher operation and maintenance costs. Cost estimates should include electrical use and replacement parts based on a 20-year time period. The table on the left summarizes estimated system costs and is intended to serve as a guide for general planning purposes.

Shared Systems May Reduce Cost

- ☐ Individual systems must be designed to accommodate high peak flows. With shared systems, not all households are likely to generate maximum flow simultaneously, allowing peak flows to be spread among several users and reducing maximum flow design.
- ☐ Substituting one larger shared treatment unit for individual systems sometimes can be more cost effective.
- ☐ It is usually easier to establish maintenance contracts.

Regulatory Issues and Constraints

- ☐ State and local regulations may not support the use of alternative treatment technologies.
- ☐ Local zoning approval may be required for a system within setback distance from wetlands and surface waters.
- ☐ Have regulator agencies established standards for both small-scale alternative systems and larger package plants?
- ☐ Are regulations in place for water reuse and reclamation?
- ☐ Is the particular technology approved for use with or without a variance application?

Legal and Administrative Costs for Shared Systems

- ☐ Property ownership and liability
- ☐ Cost of easements, if applicable
- ☐ Joint ownership of components on treatment lot
- ☐ Maintenance agreements for tanks and drainfield
- ☐ Lines crossing properties not served by the system
- ☐ Costs involved with crossing roads
- ☐ Clearance from other utility lines

References

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Joubert, L., P. Flinker, G. Loomis, D. Dow, A. Gold, D. Brennan, and J. Jobin. 2004. *Creative Community Design and Wastewater Management.* Project No. WU-HT-00-30. Prepared for the National Decentralized Water Resources Capacity Development Project, Washington University, St. Louis, MO, by University of Rhode Island Cooperative Extension, Kingston, RI. Available online at http://www.ndwrcdp.org/publications.cfm and through the National Small Flows Clearinghouse, Morgantown,WV.

University of Minnesota Extension Service. 1998. *Alternative Wastewater Treatment Systems*. Residential Cluster Development Fact Sheet Series. University of Minnesota.

Photo credits – NSFC denotes National Small Flows Clearinghouse. All other graphics are from URI Cooperative Extension.

For Additional Information

Further information about alternative wastewater treatment can be found at:

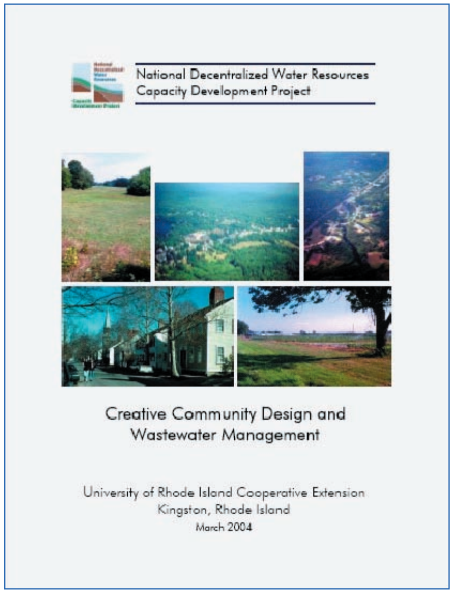
Consortium of Institutes for Decentralized Wastewater Treatment
http://www.onsiteconsortium.org/

EPA Decentralized Wastewater Treatment Systems
http://cfpub.epa.gov/owm/septic/home.cfm

National Decentralized Water Resources Capacity Development Project
http://www.ndwrcdp.org/

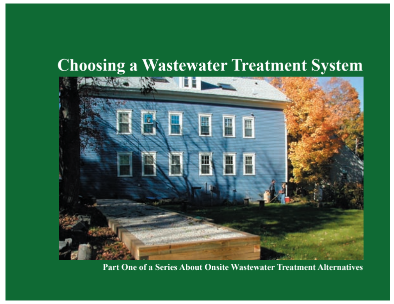
National Small Flows Clearinghouse
http://www.nesc.wvu.edu/nsfc/nsfc_index.htm

Univeristy of Rhode Island Cooperative Extension Water Quality Program
http://www.uri.edu/ce/wq



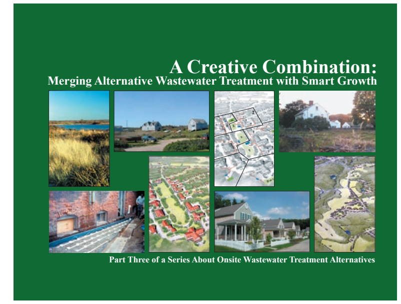
This series is condensed from "Creative Community Design and Wastewater Management", prepared by URI Cooperative Extension for the National Decentralized Water Resources Capacity Development Project (NDWRCDP). The full report is available at the NDWRCDP website at http://www.ndwrcdp.org/publications.cfm

For additional information, please consult the other manuals in this series:



Overview of conventional alternative onsite wastewater technologies available to homowners and communities

Case studies illustrating use of alternative systems as repairs to address unique site constraints and meet specific treatment objectives



A community guide to use of onsite wastewater treatment systems and creative development design to achieve more compact "smart growth" land use

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