Appendix K-2

Alternative Wastewater Options

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ENVIRONMENTAL • PLANNING • CONSULTING

National Decentralized Water Resources
Capacity Development Project





Creative Community Design and Wastewater Management

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4 ALTERNATIVE SYSTEMS FOR INDIVIDUAL LOTS

This chapter presents examples where design principles and alternative technologies described in the main community case studies are applied on individual lots. Use of alternative systems for individual lots supports the principles of creative community design by permitting compact development and in-filling, which minimizes sprawl and promotes pedestrian-friendly, distinctive neighborhoods. A community's character emerges from the sum of the look and feel of its individual lots. These real-world examples show how alternative systems permit a greater use of yard, buffers, and green space to maintain and enhance the sense of community within individual neighborhoods.

Case Studies of Alternative Systems for Individual Lots

Several of the case study systems were constructed as demonstration systems under an EPA-funded National Onsite Wastewater Demonstration Project-Phase II project in 1998. Since then, many other landowners have installed alternative technologies for either new construction or repairs in sensitive coastal areas and other resource protection zones. These examples explore selection factors related to treatment performance, environmental protection, and site constraints. Although site design and system selection are highly dependent on site conditions, checklists are provided as basic guides to system design on individual lots with factors to consider in evaluating use of individual versus cluster systems.

The reasons to select a particular system over another are many. They include:

- Space limitations
- Treatment requirements
- Reliability and risk of hydraulic failure or inadequate treatment
- Availability and ease of support from companies supplying treatment components
- Aesthetics
- Life cycle costs (not just initial installation cost) including maintenance, repairs, and energy costs over a several year period

In most examples presented here, the treatment objective was to protect pathogen- and nitrogen-sensitive coastal waters and, in some cases, protect private drinking water wells.

A High Water Table, Stony-Soil Coastal Site with a Town Water Supply

The use of an alternative treatment system on this real-world site maintained distinctive natural and architectural features of the neighborhood while protecting public and environmental health. This one-third acre site located in a nitrogen- and pathogen-sensitive coastal watershed is almost completely surrounded by a wetland, has wet glacial till soils, many stones and large boulders, and groundwater at the surface for several months during the wet season. The home on the site and the surrounding neighborhood is serviced by a town water supply.

The existing system for this site, which was pumped four times a year, consisted of an approximately 500-gallon cesspool and auxiliary drainfield line. Shallow ponded water was present over the existing cesspool area during wet times and would flow through a neighboring lot and then into the nearby coastal wetland.

A typical size filter for a three-bedroom home is 8 feet by 20 feet. The typical conventional septic system fix would completely alter the yard and most of the yard area would be required (Figure 4-1). Boulders would need to be excavated and trees removed, 4 feet of gravel fill would be brought in to raise the drainfield above the water table, and a pump would be installed to pump septic tank effluent up to the raised drainfield. Without a level area 25 feet surrounding the drainfield, retaining walls would need to be constructed to contain the fill material. Because of all this excavation and fill material, the cost of this system would far exceed the cost of the alternative system. This type of work often drastically alters stormwater movement in the immediate neighborhood and aggravates already wet site conditions.

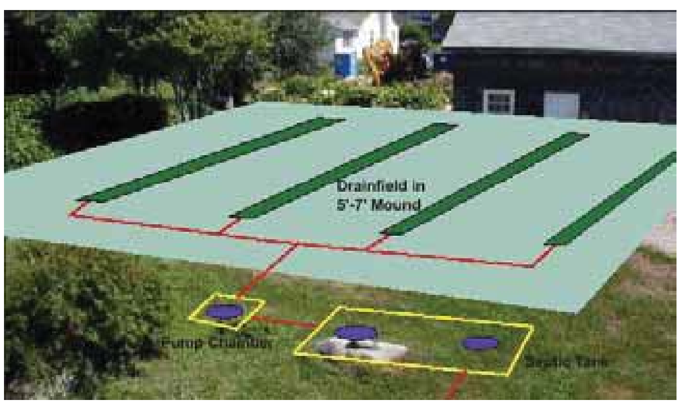

Figure 4-1
Typical Conventional Septic System

To overcome these problems, a recirculating media filter was selected as the treatment unit, with a bottomless sand filter drainfield to provide additional treatment. This system provides a minimum of 50 percent nitrogen removal to help protect nearby coastal waters. As shown in Figure 4-2, wastewater from the house flows into a septic tank with two pumps controlled by separate timers (A). One pump recirculates effluent to a media filter (B), and the other disperses this blended effluent to the raised bottomless sand filter, that is located on the highest point in the yard (C).

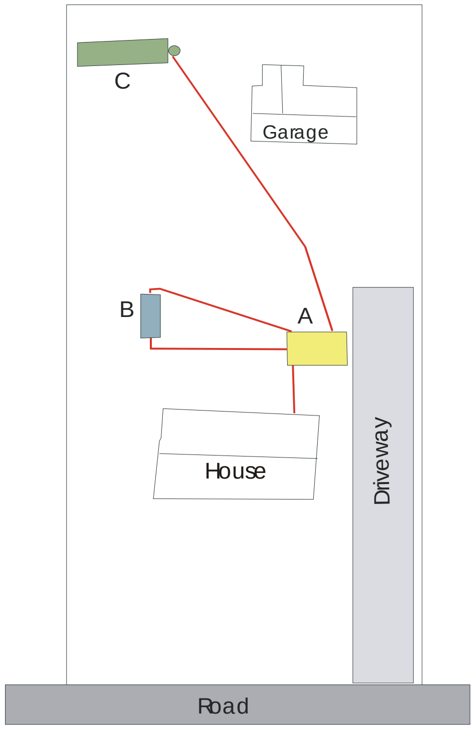

Figure 4-2
Layout of the High Water Table, Stony-Soil Coastal Site Treatment System

The media filter was selected for its small footprint and nitrogen reducing performance. The bottomless sand filter (Figure 4-3) was the only drainfield option available for this high water table site that provided bacterial reduction and avoided large amounts of fill material. This system significantly minimized site disturbance and surface topography changes that would have altered stormwater movement; at the same time it achieved a high degree of nitrogen reduction and moderate levels of bacterial reduction.

Figure 4-3
Bottomless Sand Filter Before the Final Cover of Peastone

The alternative system fits into the landscape, amid boulders and trees while providing a much higher level of treatment than a conventional system (Figure 4-4).

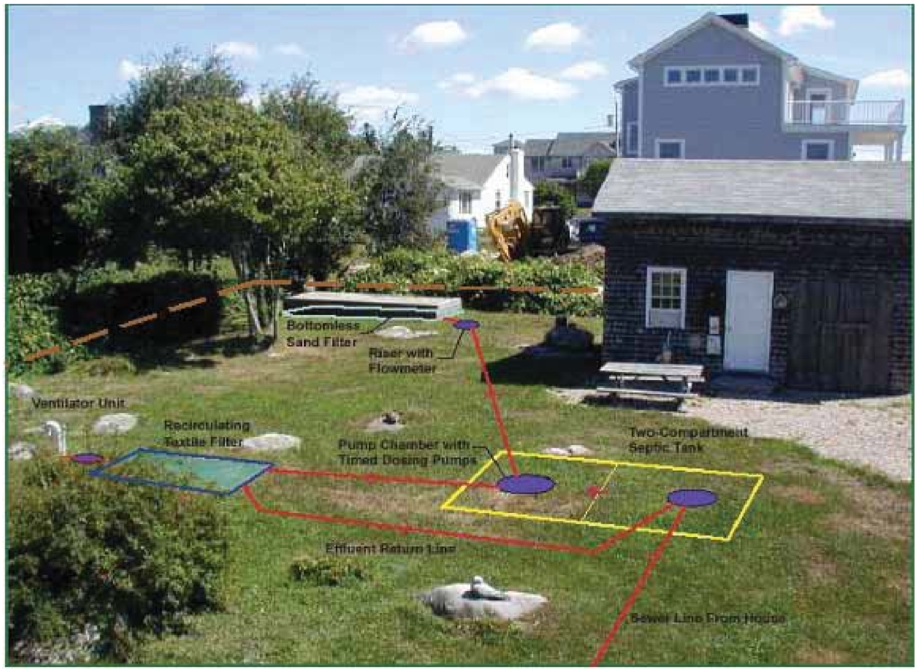

Figure 4-4
The Alternative Treatment System's Layout Fits into the Landscape

Small Flat Coastal Plain Lot with Nearby Private Wells

In this real-world example of a working class summer resort neighborhood, the creative design goal was to maintain the architectural and natural elements of the neighborhood by avoiding large obtrusive raised fill-type wastewater treatment system that would detract from the sense of community and compound stormwater problems. Homes in this low-lying sandy soil coastal plain area are largely seasonally occupied but often experience intense summer use. This entire community relies on wells, many of which are shallow-dug wells that rely on thin freshwater lenses floating above the heavier saltwater. This home, like most of the older homes in the neighborhood, is 1950s- to 1970s-vintage on a small lot (5,000 square foot is common), where well and septic system setbacks are rarely met. Wells on both the case study site and a neighboring lot were approximately 50 feet from a failed cesspool. Obviously nitrogen and pathogen removal are essential to protect groundwater supplies as well as the nearby poorly flushed coastal pond.

To save limited space, a modular recirculating media filter was placed under a cantilevered room of the house, leaving the remaining 15-foot by 50-foot usable space in the back yard for the septic tank and shallow narrow drainfield.

Figure 4-5 shows the final system layout for this flat coastal-plain site with nearby shallow wells. The system included a septic tank (A), media filter (B), and drainfield (C).

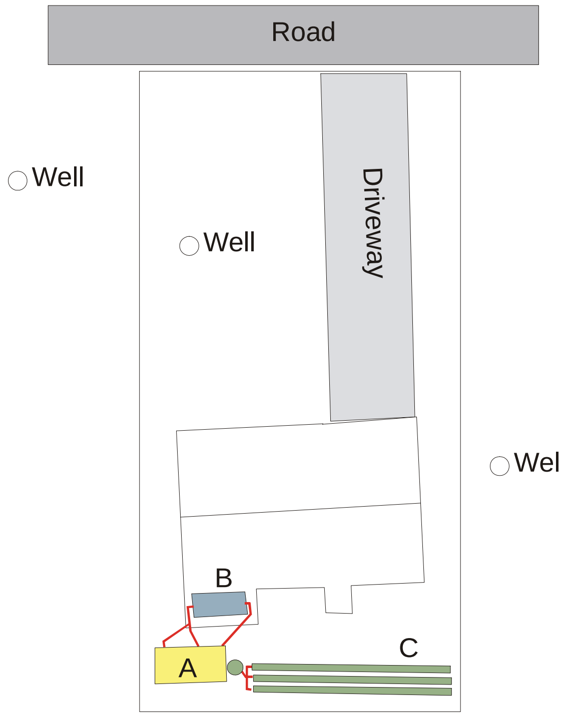

Figure 4-5
Final Treatment System Layout

Wastewater from the home enters the septic tank, where it then recirculates to the media filter in the crawl space, then is dosed to the shallow narrow drainfield where additional treatment occurs (Figure 4-6). The coastal pond can be seen in the background of Figure 4-6, approximately 300 feet away. The recirculating media filter fits in the crawl space under the cantilevered room of the house (Figure 4-7). The owners of the white building seen beyond the outdoor stairs in Figures 4-6 and 4-7 later installed a similar system.

Figure 4-6
Locations of the Final System Components

Figure 4-7
Recirculating Media Filter Under a Cantilevered Room

A Sustainable and Healthy Home Landscape

Maintaining a sustainable home landscape by removing nitrogen was a prime objective on this real-world one-third-acre lot located in a flat coastal plain with sandy soils and eight-foot-deep water table. Homes in this area are typically 1950s vintage, with about half occupied year-round. Typical of the area, the existing system consisted of a cesspool that had hydraulically failed and was surfacing. A conventional system could have easily been accommodated, but with little nitrogen treatment.

One of the homeowner's main concerns was maintaining a vigorously growing turf on his landscaped lawn. To satisfy the owner's request, the system selected for this site was a septic tank followed by a pump tank that dosed a drip-irrigated field. The drip irrigation tubing was installed six inches below ground surface to maximize nutrient and moisture use by grass. Although the yard was large enough to accommodate most any technology, the drip irrigation fit well on the site because there was sufficient level space to accommodate the required amount of drip tubing. Figure 4-8 shows the location of the system components.

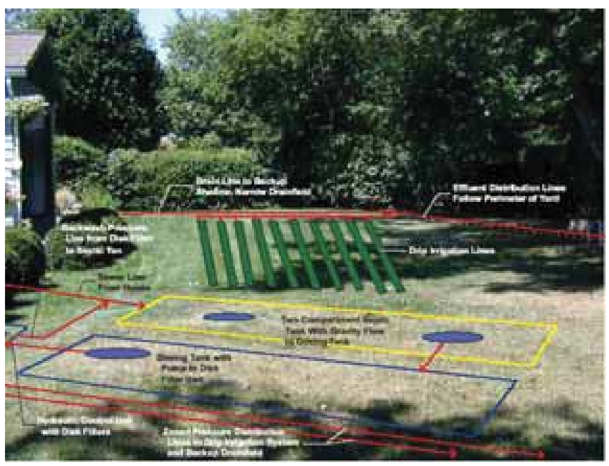

Figure 4-8
Drip-Irrigation System Layout for Turf and Landscape Maintenance

Figure 4-9 shows a diagram of the layout for the drip-irrigation system. In this system, wastewater from the home enters the septic tank (A) where solids settle. Effluent flows to the dosing tank (B) and is pumped through disc filters that remove fine organic particles that might clog the drip irrigation lines (C). A sand-lined shallow narrow drainfield (D) was also installed as a backup to the drip field but has not been used.

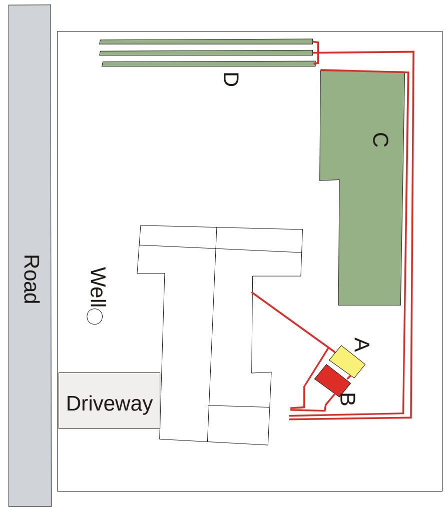

Figure 4-9
Layout of a Drip-Irrigation System

Site with a Nearby Private Well and Unique Wetlands

Maximizing pathogen and phosphorus removal were the treatment concerns on this real-world one-half-acre sandy soil lot relying on well water and having a small, yet environmentally important, vernal pool nearby. Several homes in this portion of the community have these natural vernal pools that are a unique habitat for threatened species of amphibians. The existing bed-type drainfield for this site had failed and was threatening the vernal pool. The somewhat rolling local topography with a high water table at about three feet, lent itself to using a buried single-pass sand filter with a shallow narrow drainfield. This system was used to provide maximum bacterial removal on the three-foot water table site, protect the drinking water well, and maintain the greatest setback from the vernal pool approximately 60 feet from the drainfield.

A generic single-pass sand filter was selected for this site because it is a reliable pathogen removal technology used for more than 100 years to treat water and wastewater. The single-pass sand filter is more effective in removing bacteria than a recirculating filter, which excels in nitrogen reduction. In addition, single-pass sand filters are larger than recirculating media filters and space was available at this site. The shallow narrow drainfield can be expected to provide additional nitrogen and pathogen removal to protect groundwater, and phosphorus treatment to protect the vernal pool from nutrient enrichment.

Figure 4-10 shows the system layout. Wastewater from the home enters the septic tank (A) and this effluent is then dosed to the single pass sand filter (B). Final treated effluent is then dispersed to a shallow narrow drainfield (C).

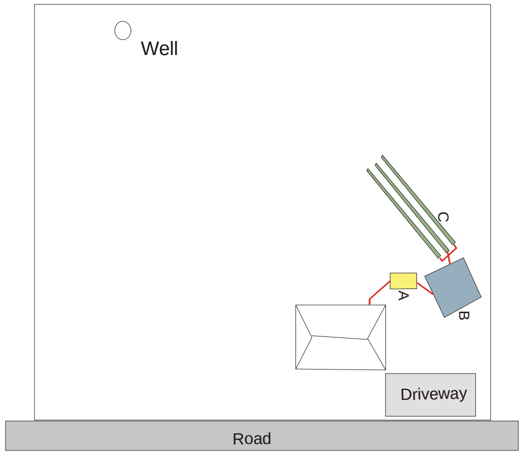

Figure 4-10
Layout for the Single-Pass Sand Filter System

This system required little site alteration, which prevented disruption of the wetland buffer and enabled existing landscaping to remain, including a small tree and several shrubs (Figure 4-11). The conventional septic system option would have required clearing, regrading, and filling to adjust for slopes and to raise the drainfield at least two feet to achieve the required separation to groundwater.

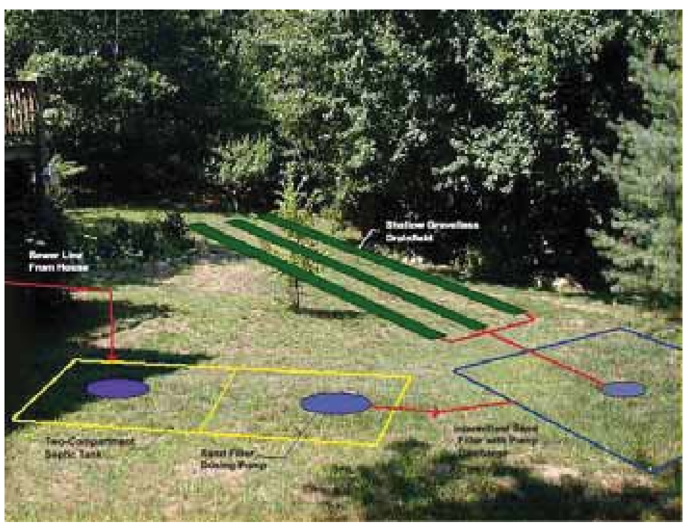

Figure 4-11
Location of System Components

Sandy Shorefront Lot with Limited Space

This real-world example site is located directly on the shore of a nitrogen-sensitive coastal pond that has been closed to shellfishing due to high bacteria levels. Nutrient enrichment at the shoreline of this property has caused an overabundant growth of nuisance algae (Figure 4-12).

Figure 4-12
An Overabundant Growth of Nuisance Algae Caused by Nutrient Enrichment

The creative community design goal in this case study was to maintain a sense of community character and charm while protecting the coastal pond and nearby well from nitrogen and bacteria. With a total land area of 5,000 square feet, the site has extremely limited usable space to fit house footprint, septic system, well, and parking area. The failed system consisted of two 55-gallon steel drums, an approximately 300-gallon steel septic tank, and a 600-gallon cesspool all in series. Located between the house and the pond shore, a dug well drawing from a shallow freshwater lense provided water to the 1950s vintage home.

The system installed on this site consists of a septic tank, a recirculating media filter, and a shallow narrow drainfield. Figure 4-13 shows the system layout. Wastewater from the house enters the septic tank (A) where effluent is then pumped to the recirculating media filter (B). The treated effluent is dosed to a two-zone shallow narrow drainfield (C1 and C2).

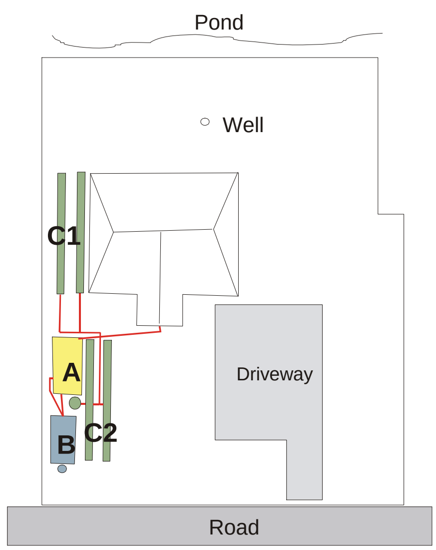

Figure 4-13
Layout for a Recirculating Media Filter System for a Lot With Limited Space

Figure 4-14 and Figure 4-15 show various views of the recirculating media filter system for this tight lot. One-half of the shallow narrow drainfield is located under the clothes line in between the home and the fence at the lot line (Figure 4-15).

Figure 4-14
Recirculating Media Filter System on a Small Lot

Figure 4-15
The System's Drainfield is Located Between the Home and the Fence

Until a few years ago, the conventional option for such small lots with deep sandy soils would have been a septic tank followed by deep concrete leaching chambers. This type of system has an extremely small footprint (4-foot by 12-foot drainfield) but provides little treatment. Shallow concrete leaching chambers could have been installed in the driveway, but again little treatment would have resulted.

Sloping Landscaped Site in a Sensitive Coastal Watershed

This real-world sloping one-half-acre lot has rocky glacial-till soils, well-established landscaping, and many obstacles that render the site with little usable space in which to fit a conventional septic system repair. Although the site has a fairly deep water table and municipal water service, the adjacent coastal pond roughly one block away is sensitive to nitrogen and bacterial inputs. Using alternative technology on this site eliminated extensive filling and regrading of the existing lot and maintained the natural elements of the landscape.

Whatever technology that was chosen for this site needed to fit into an area under an existing raised deck on the house to save space and fit the existing landscaping (Figure 4-16).

Figure 4-16
The Existing Raised Deck

The technology selected was a septic tank with a pump dosing a single-pass modular media filter. Figure 4-17 shows the system layout. Wastewater from the house enters the septic tank (A) where effluent is dosed to the single-pass media filters (B) located under the deck. Treated wastewater flows through an ultraviolet light disinfection unit (C) and then is dosed to the shallow narrow drainfield (D) adjacent to an existing fern garden (Figure 4-18).

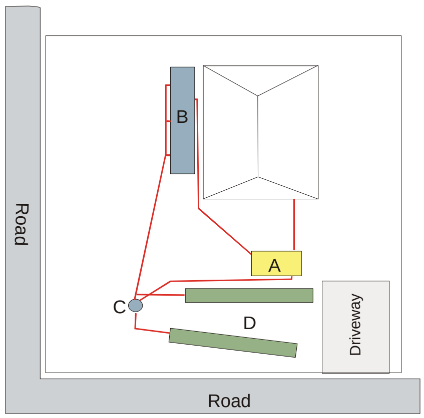

Figure 4-17
System Layout for a Sloping Site Where Bacteria Removal is Important

Figure 4-18
Locations of System Components on the Site

The media filters come in pre-packaged modular units that provide flexibility in siting, simplify installation, and enable limited site disturbance to the lot during construction (Figure 4-19). The UV light disinfection unit provides an additional level of bacterial removal to help reduce the pollution risk from this system. Due to the slope on this lot, a conventional system would have required extensive clearing with large amounts of machine time and gravel fill to enable level areas for drainfield lines, all with little nitrogen removal.

Figure 4-19
Modular Single-Pass Media Filters

A System for Tiny Waterfront Lots

Tiny waterfront building sites are lots that really should never have been built upon. They are grandfathered postage-stamp-sized lots with homes that had little impact on water quality back when first built. But now, with years of infill development and the shift to year-round use, the former summer cottage neighborhood has hastened the loss of recreational and commercial use of a waterbody for fishing and shellfishing.

This example is one such lot (Figure 4-20), located on the shore of a poorly flushed coastal pond that is permanently closed to shellfishing due to bacterial levels and is also showing signs of nitrogen enrichment. This example illustrates the use of alternative technology to maintain the quaint charm of a neighborhood and enable the landowner to renovate and revitalize his home. This roughly 4,000-square-foot-lot has unusually limited space, and a conventional system would neither fit on the site nor would it protect the beleaguered pond. Even most advanced treatment systems would not fit in the available space on this lot.

Figure 4-20
The Existing House Was Originally a Seasonal Home with a Building Footprint of Less Than 600 Square Feet

With remodeling, the footprint was slightly enlarged (Figure 4-21). The number of bedrooms remained the same, keeping potential occupancy at the same level and preventing an increase in nutrient loading.

Figure 4-21
Remodled House with a Slightly Enlarged Footprint

To meet the space and treatment demands of this site, a system incorporating fixed activated sludge technology was installed. This is a space-saver system because the treatment unit itself actually rests within the septic tank (Figure 4-22), eliminating the need for separate space to fit the treatment unit.

Figure 4-22
The Treatment Unit

Figure 4-23 shows the system layout. Wastewater from the house enters the septic tank (A) and flows through the fixed activated sludge system (B). Treated wastewater flows through an ultraviolet light disinfection unit (C) and then is dosed to the shallow narrow drainfield (D). Figure 4-21 also shows the location of system components.

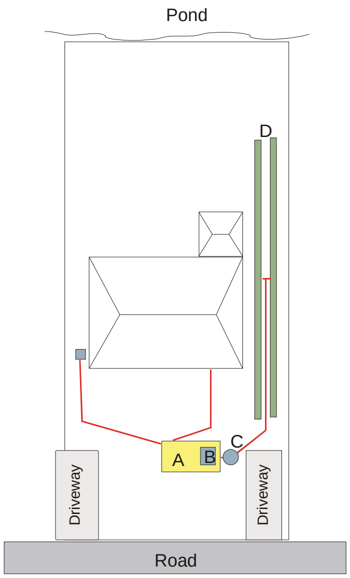

Figure 4-23
The Treatment System Layout

A recirculating media filter would have also been appropriate for this site, but would have used more space. This technology minimizes inputs of nitrogen and bacteria from this particular lot, protects the receiving waterbody, and has the smallest footprint possible.

Aesthetic Hints for Alternative Systems

This section attempts to provide an understanding of some basic system placement, setback, landscaping, and aesthetic issues that often make or break a system in the eyes of the property owner and neighbors. Although it is the designer's responsibility to make sure the system meets all these parameters, it is advantageous for planners to have basic knowledge about how a system should look, how it can fit the home landscape, or how it can blend into a subdivision without looking obtrusive. The following examples illustrate situations where more thought on the aesthetic impacts of a system and its influence on use of the home landscape may have produced a finished product that the system designer, installer, owner, and even neighbors might appreciate.

Simple Changes to Enhance Treatment System Choices

On this small flat coastal plain lot located in the watershed of a nitrogen-sensitive coastal pond, a recirculating media filter was installed to achieve a state-imposed discharge standard of at least 50 percent total nitrogen reduction. Although this technology was a good choice for this area from a treatment and space allocation perspective, the designer insisted on using a conventional (gravity-fed) drainfield. The media filter serves the house on the left in Figure 4-24 (only a corner is barely visible) the fence behind the tank and filter marks the adjoining property boundary with the house in the background.

Figure 4-24
Single-Family Home With a Raised Recirculating Media Filter and Conventional Gravity-Flow Drainfield

The recirculating media filter, which is raised well above the original ground surface and landscaped with native shrubs, uses up more space than actually needed. The raised area effectively limits the owner's use of that portion of the property and creates an aesthetic issue (in this case with several neighbors).

Incorporating the following simple changes would have enabled the homeowner greater use of the yard space. First, tank risers should be trimmed flush with the ground surface so a lawn mower can move directly over them. A second pump could have been used to dose a shallow narrow drainfield rather than using a conventional gravity-fed drainfield. This approach would have required one more pump, but the advantages would be:

- The media filter would be flush with the ground surface and would blend into the existing landscape more easily.
- A shallow narrow drainfield could have been installed easily with minimal disturbance of the yard.
- The shallow narrow drainfield would also provide additional wastewater treatment.

Recent studies show additional nitrogen removal rates in shallow drainfields average 50 percent annually (Stolt et al., 2003).

Paying Attention to the Details

An important consideration when selecting a treatment system is how the system will blend in with surrounding properties. Figure 4-25 shows a site with a demonstration system (foreground) with a shallow narrow drainfield—apparent by the greener grass.

Figure 4-25
A Conscientious Installer Paid Careful Attention to Details and Lined Up the Drainfield Lines on These Two Separate Lots to Produce a More Orderly and Aesthetically Pleasing Look

When the neighbor to the rear decided to replace his system with a similar advanced treatment system, the installer took care to line up the drainfields for a neater look. This is a minor point, but a nice touch from an installer who puts extra thought and effort into system aesthetics.

Options for Placement of System Components

Two adjoining lots in a coastal pond neighborhood upgraded failed septic systems using advanced decentralized treatment systems. Recirculating media filters followed by bottomless sand filter drainfields were used on each lot to achieve nitrogen and pathogen removal, fit on a small lot, and accommodate high water table conditions. The orange line shown in Figure 4-26 marks the property boundary, the treatment unit is outlined in yellow, and the bottomless sand filter is on the right of the pine tree.

Figure 4-26
An Example of Component Placement Options

Unfortunately for the homeowner, the system components became the focal point of the landscape when placed in highly visible, open areas. An alternative placement scenario could have been to site the treatment unit along the property boundary, as shown in the foreground. The bottomless sand filter could have been designed as a long narrow rectangle and sited along the hedge line to the right of the current location, as shown with the dashed blue line. In addition to fitting the site better and opening up more usable space, a long rectangular bottomless sand filter configuration actually functions more effectively, and is easier to install and maintain.

In the adjoining lot (Figure 4-27), similar redesign would have enabled greater use of the property and avoided the need for costly landscaping to camouflage treatment units. The property boundary, as shown by the orange line, extends beyond the photo to the left, with space at the corner of the property, left of the telephone pole, for the treatment unit. The bottomless sand filter, located in front of the shed at the rear of the property, currently blocks the shed door, preventing it from opening fully. The bottomless sand filter could have been designed in a long rectangular shape and sited along the hedge following the property boundary on the left.

Figure 4-27
An Additional Example of Component Placement Options

These examples offer basic helpful tips to help systems blend into the home landscape so system owners and neighbors appreciate the flexibility of the technology and do not view it as an eyesore.

Fitting Alternative Systems into the Landscape

The following checklist provides guidance for fitting alternative systems into the landscape:

- Work with the existing topography, buildings, and vegetation to blend components into the landscape.
- Use grade changes to avoid an additional pump. For example, recirculating systems typically pump effluent from the septic tank to the top of the treatment unit. The treated wastewater exits from the bottom the treatment unit and returns either to the septic tank or a different recirculation tank. When using a recirculating system, locate the bottom of the treatment unit upgradient of the inlet of the recirculating tank, thereby allowing gravity flow back to the tank.

- Treatment units above ground need to fit into the landscape unobtrusively.
- Place components along existing edges such vegetation borders, shrub rows, driveways, or stone walls. Whenever possible avoid putting units in the middle of lawns or other open spaces.
- Conceal vent pipes from general view by siting them behind vegetation, stone walls, or buildings.
- Use natural materials, such as wooden timbers, to encase the sides of treatment units.
- Small modular treatment units can be tucked into crawl spaces and under decks provided access is maintained.
- Where possible, locate treatment units and drainfields away from high-use areas. This consideration becomes more important for larger systems and commercial properties. For example, treatment units should be kept away from restaurant entrances and outdoor patios.
- Electrical panel boxes can be noisy when switches controlling pumps go on and off. Locate these on the outside of utility walls or in high-use areas such as garages, entryways, or kitchens where refrigerators, air conditioners, or other utilities already create some noise.
- Keep in mind the convenience and safety of maintenance providers. Locate the panel box for easy access. Consider locating the panel box outside fenced pet areas for the inspector’s convenience and safety.
- Insert activated charcoal pads at the top of drainfield inspection ports if odors are a problem.
- When locating shallow narrow drainfields in playing fields, cover inspection ports with turf for safety, but tag them beforehand with metal markers to easily identify them with a metal detector when maintenance is due.

Selecting Between Individual and Cluster Systems

The decision to use an individual system or a cluster system for two or more homes is highly site specific. Shared systems may cost more or less than several individual systems. Nevertheless, the following factors provide guidance in this decision.

- Consider if a reduction in design flow be allowed with a shared system. With individual systems, enough capacity must be provided for the worst case, maximum flow scenario. With several homes on one system, the risk that all units will experience maximum flow at the same given time is slim, so design flows for each may be lowered because peak flows from some units will be moderated by the group. Reducing peak flows increases cost-effectiveness, but regulators determine if credit is allowed.
- If the lot is too small for a system, try talking with a neighbor who may also need a system fix. The homeowner donating his extra lot as a treatment zone lot for a shared system may qualify for a tax break when the lot is deemed as unbuildable.
- There is no assurance that cluster systems will save costs due to the need to multiply treatment units and the cost of wastewater collection.

- When more than five or six houses are connected, there is potential for greater savings due to reduced design flow, a single treatment unit, and potentially fewer pumps.
- Determine if public property is available for a common treatment and drainfield area. Saving on land acquisition costs can make a shared project much more cost effective.
- Where private wells are located within 100 feet of a soil infiltration system, consider upgrading to advanced treatment to protect drinking water quality.
- Where shallow wells are located within 100 feet of a wastewater treatment system, consider installing a drilled well.
- Collection systems for alternative cluster systems serving anywhere from two homes to a whole village all require piping to carry wastewater from homes to the shared treatment units and drainfields. Typically small diameter (two- to three-inch diameter) pipes are used.
- Compare the cost of a septic tank effluent gravity collection system versus individual system repair.
- Determine if local regulations allow connection of small diameter effluent sewers to a nearby gravity sewer rather than installing a conventional (and generally more costly) traditional pump station.
- Rely on conventional treatment systems using gravity flow in areas of large lots with good soils and where advanced wastewater treatment is not essential to protect public health or environmental quality. With good soil and site conditions, conventional onsite systems generally provide reliable treatment with the least cost and lowest maintenance.
- Use of active systems should be justified with measurable improvements in health and the environment (Tyler, 2000). Active systems that provide only minimal improvements, such as reduced BOD and TSS, and reduced drainfield size, should be carefully evaluated.
- Consider electrical costs, which can add up over the life of a system and offset any minor savings in initial installation cost, especially in island locations where electricity costs are generally much higher than normal.
- When selecting advanced treatment systems of comparable complexity, reliability, and cost, it makes sense to choose the simplest technology.