Planning Issues for On-site and Decentralized Wastewater Treatment

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Special thanks are due to Mary Hooper, who helped entice us into the exciting world of sewage and supported our first research projects. Our deepest love and gratitude is due our wives, Denise Green and Bonnie Alpert, respectively, who supported our perverse interest in sewage and wastewater even after our careers, seemingly, were moving us away from this field.

Cover design by Lisa Barton; this report is printed on recyclable paper.

Cover photo by Peter Finnie. The U.S. Environmental Protection Agency reports that as much as 33 percent of new development in the U.S. relies on decentralized wastewater treatment. The dual objectives of effective planning for these systems are siting them so that they both operate effectively and meet community growth objectives. In order to achieve both objectives, planners, not engineers and sanitarians, should be coordinating discussions about which areas should be served by these systems. Successful results can mean a cleaner environment, safer drinking water, and the type, placement, and density of development responsive to the residents' vision for their community.

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Sewage disposal is one of the key factors in determining the feasibility of land development. In urban areas, including many dense towns and some suburban areas, we typically pipe our sewage (i.e., through the “sewerage system”) to a sewage treatment plant and then ultimately discharge it into a body of water (i.e., the “centralized system” process). Vast areas of the U.S. and the world, however, do not have centralized sewage collection and treatment facilities. In these areas, sewage must be disposed of on-site or in adjacent community or cluster systems. These treatment systems are on-site and decentralized sewage treatment and disposal systems (sometimes called septic tank-soil absorption systems or septic systems).

Without centralized sewage collection and treatment, the limits of natural systems, especially soils, to treat sewage can be the greatest single limiting factor to development. Decentralized wastewater treatment systems, even for single-family homes, were often considered by many people "an inadequate or temporary solution until sewers could be connected" (EPA 1980, iii; Siegrist 2001). As early as 1980, however, the U.S. Environmental Protection Agency (hereinafter EPA; if a state EPA is referred to, we will incorporate the state name) acknowledged that, at least for single-family homes, "such systems, if constructed and maintained property, can provide a reliable and efficient means of wastewater treatment and disposal at a relatively low cost" (EPA 1980, iii). EPA continued "On-site systems are now gaining desired recognition as a viable wastewater management alternative that can provide excellent reliable service at reasonable cost, while still preserving environmental quality" (page 2). The agency still referred to decentralized systems as an "alternative" to centralized sewerage systems often best suited only for low-density, single-family home development.

The EPA's current position (2006) on decentralized treatment systems is:

> When properly sited, designed and maintained, these systems are capable of producing high quality wastewater. However, decentralized systems are the second greatest threat to groundwater quality, second only to leakage from underground storage tanks. It is estimated that nation-wide, 10 to 20 percent of decentralized systems are not adequately treating wastewater due to inadequate site location, design and maintenance. (EPA 2005b).

Since the 1970s, much of suburban development in the U.S. has occurred at densities inadequate to support sewerage systems. As a result, decentralized wastewater treatment is serving ever more Americans. EPA reports that 25 percent of U.S. homes and 33 percent of new development rely on decentralized wastewater treatment (EPA 2003). Table 1 provides more detail on what types of units have decentralized wastewater treatment, based on U.S. Census data.

Since the 1970s, much of suburban development in the U.S. has occurred at densities inadequate to support sewerage systems. As a result, decentralized wastewater treatment is serving ever more Americans.

TABLE 1. ONSITE SEWAGE DISPOSAL IN OCCUPIED HOUSING UNITS*

	Total Units	Owner-Occupied	Renter-Occupied	Units Built within four years	Mobile Home
Septic Tank, Cesspool, Chemical Toilet	21%	27.2%	7.7%	28.3%	55.0%

*As percent of all occupied units of the same category
Source: U.S. Census Bureau 2001.

In some areas of the country this rate is much higher. Decentralized systems are more common in rural areas than urban areas. Outside of metropolitan statistical areas, 45 percent of homes use decentralized wastewater treatment (U.S. Census Bureau 2001). EPA also reports that their use varies significantly from state to state, ranging from approximately 55 percent of Vermont and 48 percent of North Carolina residences to 10 percent of California residences. Decentralized systems are found almost everywhere, even in the most urban areas, such as the 575 units in the District of Columbia (EPA 2002).

In many areas, improper sewage disposal from decentralized systems poses a great threat to surface water, groundwater, and water supplies. Nitrogen can pose a health risk to infants and create algal blooms in estuaries and oceans. Phosphorus can spark wild algal and plant growth in lakes and inland waters. Pathogens from sewage (disease-causing viruses, bacteria, parasitic protozoa, Helminthes or parasitic worms, and, although almost certainly not relevant to sewage, prions) create the greatest health risks from sewage and can contaminate surface waters and water supplies.

Ten percent of U.S. decentralized wastewater treatment systems back up into homes or discharge onto the surface of the ground, and 20 percent may be malfunctioning to some degree. More than half of U.S. decentralized wastewater treatment systems are more than 30 years old and probably do not meet current standards (EPA 2003). While landowners are usually aware when their systems are backing up into the house or surfacing, they are often not aware of systems that contaminate the groundwater, so, in fact, the failure rate could be much higher.

In 1996, states reported that improperly operating decentralized wastewater treatment systems are a leading source of 36 percent of environmentally damaged ocean shoreline and the second-most-sited threat to groundwater resources (EPA 2003).

Well-functioning decentralized wastewater treatment systems can provide excellent sewage treatment, but only when they are well designed and sited. They can function as effectively and permanently as centralized treatment facilities and are generally more cost-effective (GAO 1994; EPA 1997). In the authors' experience and based on the performance of many centralized and direct discharging wastewater treatment systems, it is clear that many decentralized systems are superior to centralized treatment.

Planners are not generally the primary profession dealing with sewage disposal issues. Unfortunately, this often means no one is adequately considering the huge influence that soils and sewage disposal technologies have on development (e.g., see Schiffman et al. 2003).

Other professionals, such as engineers, sanitarians, and soil scientists, deal with the design of sewage disposal facilities, both centralized and decentralized. Planners, while not generally designing wastewater treatment systems, often are involved with two key aspects of wastewater planning: decentralized sewage facility management, and land-use and capital planning.

Decentralized sewage treatment management, which sometimes requires sophisticated institutional controls to work properly, draws upon some of the core skills of planners. Planners are often involved with management aspects through subdivision regulations and subdivision and other permit approvals. In addition, planners are often involved with the most aggressive management approaches, such as waste management districts. In these districts, institutional controls ensure that private or public entities monitor and maintain decentralized treatment systems. The waste management district in South Kingston, Rhode Island, which is discussed in more detail later in this report, for example, was created through a joint effort with South Kingston's Planning Department

Planning for which areas in a community are served by centralized sewerage systems and which areas are served by decentralized systems are critical aspects of growth management. As such, planners need to be involved with these decisions as part of the land-use planning, capital planning, and subdivision and land-use permit processes. Ideally, planners, not engineers and sanitarians, should be coordinating community discussions about which areas should be sewered and which areas should be served by decentralized wastewater treatment to achieve community goals.

Decentralized wastewater treatment, especially in certain soils and near sensitive environmental receptors, such as coastal waters and water supplies, can limit density. Current technology and practice, however, are changing some of these assumptions. Variable grade sewers, for example, can dramatically lower the cost of extending centralized sewerage treatment collection in areas with low density (see sidebar).

ALTERNATIVE SEWERAGE COLLECTION

Traditional centralized sewage collection facilities (sewerage systems) use large diameter gravity systems supplemented by pressure mains to collect wastewater. To collect wastewater without clogging, traditional gravity systems must be relatively deep and use relatively large diameter pipes sloping at a consistent grade, which results in very expensive construction. When grades do not allow gravity to work, systems typically use traditional pressure mains from a low point in the system up to a point where gravity will work again. These pressure mains require expensive grinder pumps, which grind up wastewater so that it does not clog the pipes, as well as back up pumps and back up power supplies.

In most alternative sewage collection systems, wastewater generators discharge their waste into a septic tank. The septic tank then discharges into a centralized sewerage network. Because solids have settled into septic tanks before being discharged into the system, the systems have much lower volumes of solids. This allows smaller diameter pipe, variable grade layouts, and sewage effluent pumps discharging into the system that are much less expensive than grinder pumps. In addition to allowing much lower installation costs, the wastewater generator, not the sewage collection agency, typically own and maintain the pumps.

Alternative sewerage methods are generally available at lower cost. Public works agencies sometimes resist these systems. These agencies often are concerned about management because there are always risks with new technologies and because their application may be limited to specific soils and sites. Meanwhile, planners and communities often resist these systems because they have the potential to open up new land to development.

Innovative and alternative decentralized treatment systems can allow sewage treatment in areas previously considered unbuildable. For example, sites with high groundwater or ledge might use raised pressurized mounds, sand filters, or other fixed filter systems that replicate some of the functions of native in-place soil. Because these systems partially replicate soil-based systems, they can work on sites where many traditional soil-based systems cannot work. As a result, they can open up new land to development, all too often without proper planning.

Clustered and small community decentralized wastewater treatment systems can treat dense villages and development clusters. In these systems, wastewater is piped from individual wastewater generators to a community site where soils are adequate to provide treatment, sometimes on a site planned to become a community park or parking lot. These systems may be built at much lower cost and may make more land available for development.

Sewage disposal is such a pervasive issue in many small and suburban communities that in many areas it can be the most critical factor in determining if land can be developed. The professionals who design decentralized systems summarize this pervasiveness (which perhaps says more about their personality than anything else) by pointing out that if you add a tad of water to a sewage storage tank, you still have a sewage storage tank, but if you add a tad of sewage to a water storage tank, you create a new sewage storage tank.

In some areas, decentralized water treatment regulations are used, deliberately or not, as de-facto zoning regulations. Development is allowed only in areas that accommodate sewage disposal. Unfortunately, areas that accommodate sewage disposal may not be especially good at sewage treatment. Sometimes areas with sand and gravel soils that can dispose of vast quantities of sewage (maybe into a drinking water aquifer) are favored over areas with denser soils, which can actually provide better treatment and are less likely situated atop public drinking water supplies.

Equally significantly for planners, relying on soils alone and on the densities possible with decentralized wastewater treatment systems is not necessarily consistent with other community and planning goals.

The first half of this PAS Report examines the significant adverse health effects of water contamination due to improperly functioning decentralized sewage systems, the importance of soils in the operation of decentralized systems, and types of conventional, innovative, and alternative decentralized systems. The second half considers the regulatory and management roles that planners play in the siting and evaluation of these systems. The report also contains a glossary of terms and a helpful "decision tree."

SEWAGE POLLUTANTS, RISKS, AND NATURAL TREATMENT PROCESSES

Public health officials once asked one of the authors of this PAS Report (Feiden) to conduct an investigation of elevated bacterial levels in a private, drilled well. The public health officials and property owners were convinced that the bacteria were from a malfunctioning sewage disposal system. After conducting a more thorough investigation, the author discovered that the property owners leashed their dog to their drilled well casing. The dog was urinating on the well casing, and its urine was short-circuiting along the face of the well casing to the groundwater. Move dog, problem solved.

The lesson from this story and one to consider when trying to focus on source pollution, especially when considering the many factors that make up a successful decentralized wastewater treatment system is simple: the holistic approach, which is at the heart of any good planning process, is critical to considering sewage disposal issues as well. The following paragraphs make clear the wide range of pollutants and their potential sources that all planners dealing with issues of decentralized sewage system siting, maintenance, and evaluation will need to consider.

Domestic sewage contains high concentrations of nitrogen, phosphorus, biochemical oxygen demand, microorganisms, and other pollutants. Of these, nitrogen and potential pathogens generally cause the greatest concerns from decentralized wastewater treatment systems that discharge into the soil. Biochemical oxygen demand can be significant when systems discharge or overflow into surface waters. Other pollutants, especially inorganic pollutants, can be very significant from household chemicals and from nonresidential sewage disposal systems.

Sewage disposal is such a pervasive issue in many small and suburban communities that in many areas it can be the most critical factor in determining if land can be developed.

Table 2 on page 6 provides a summery of pollutants and the removal efficiencies of these pollutants in conventional decentralized sewage disposal and treatment systems. Certain innovative and alternative systems, discussed below, can be designed to increase removal efficiencies. Although much research has been done, gaps still exist in our understanding of how systems work in real life over time (Siegrist 2001).

Nitrogen is extremely difficult to treat. Nitrogen contamination from decentralized sewage disposal poses the biggest risk to human health where drinking water supplies are drawn from aquifers located in areas with high concentrations of sewage disposal systems.

Although rare, excessive amounts of nitrogen can cause methemoglobinemia (blue baby disease). More significantly, nitrogen, a key ingredient in fertilizer and animal waste, is often the primary limiting factor for aquatic plants in coastal waters and estuaries. In other words, in these waters, sufficient sunlight, substrate, and most minerals are adequate to support plant and algal life. Only nitrogen is in short supply, thereby being the limiting factor for new plant and algal growth. Adding nitrogen to these waters can cause algal blooms and disturb shellfish beds and natural systems.

Organic nitrogen and ammonia-nitrogen (NH_3) are present in wastewater. In an aerobic (meaning in the presence of oxygen, as there should be in a leachfield), the biochemical nitrification process transforms these types of nitrogen to nitrite (NO_2 -) and nitrate (NO_3 -). The final treatment process, denitrification under anaerobic conditions (meaning, without the presence of oxygen), converts nitrite and nitrate to nitrogen gas, which is relatively inert and makes up 78 percent of our atmosphere. (See Figure 1.)

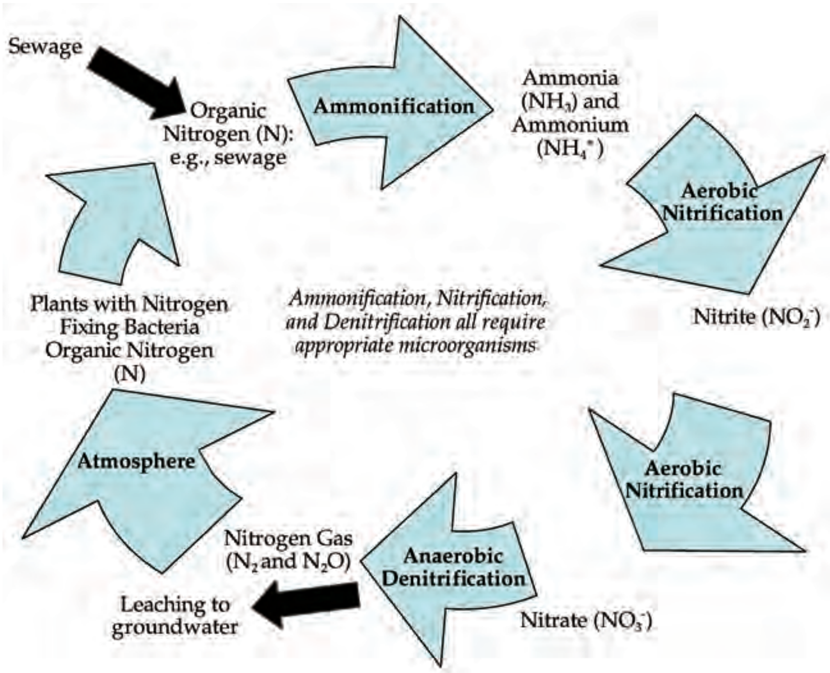


Figure 1. *Simplified nitrogen cycles.*

TABLE 2. SEWAGE POLLUTANTS

Pollutant	Description	Decentralized sewage treatment	Pollutant removal for conventional systems, with 3-5 feet of soil above groundwater
Pathogens	Disease-causing microorganisms (viruses, bacteria, protozoa, and Helminth worms)	Good decentralized systems provide excellent treatment. Some viruses and parasites can survive very long periods.	99.9 percent removal
Nitrogen (N)	Nutrient creates eutrophication in surface waters. It is typically the limiting factor in coastal waters. High concentrations cause "blue-baby' disease.	Conventional decentralized systems provide little treatment. Some alternative systems provide good treatment.	10-20 percent removal
Phosphorus (Ph)	Nutrient creates eutrophication in surface waters. It is typically the limiting factor in fresh water systems.	Good decentralized systems provide excellent treatment.	0-100 percent removal
Biochemical Oxygen Demand (BOD)	Amount of oxygen depleted from receiving waters to treat waste.	Good decentralized systems provide excellent treatment.	>90 percent removal
Total Suspended Solids (TSS) and turbidity	Solids floating in the water column and their ability to block light (turbidity). Associated nutrients, BOD, and lack of light harm the natural biota.	Good decentralized systems provide excellent treatment.	>90 percent removal
Volatile organic compounds, hazardous waste, household medicines	Hundreds of natural and manmade pollutants discharged into a decentralized system. Cause damage to human and natural biota health.	For some contaminates, often very little treatment provided. Some pollutants can damage natural biota that is critical for traditional sewage treatment.	>99 percent removal
Heavy metals (e.g., lead, copper)	Pollutants discharged into decentralized systems. Cause damage to human and natural biota health.	For some contaminates, often very little treatment provided. Some pollutants can damage natural biota that is critical for traditional sewage treatment.	>99 percent removal
Organic precursors of disinfection byproducts	Organic matter that, when combined with chlorine in public water supplies, can form suspected carcinogens. Related to N, P, BOD, and TSS	Good decentralized systems provide excellent treatment	>99 percent removal

Source: U.S. EPA 2002, and the authors. Removal efficiencies from Siegrist 2001.

In nonagricultural coastal areas, decentralized wastewater treatment systems may be the largest contributor of nitrogen to adjacent waters. In Buttermilk Bay, Massachusetts, for example, a detailed nutrient loading analysis determined that the single largest source of the nitrogen entering this sensitive coastal embayment was from decentralized wastewater treatment systems, even though 25 percent of the homes are on centralized sewers (Costa et al. 1999). Such nitrogen loading creates algal growth and can create a serious decline in the natural ecosystem's health

Phosphorus, another fertilizer ingredient, is typically the primary limiting factor in fresh water, and its addition in these waters can create algal blooms. Fortunately, in a properly functioning decentralized sewage disposal system with adequate separation to groundwater, most of the phosphorus in wastewater is removed by the soil.

Unfortunately, most communities do not pay enough attention to the health risk of sewage contaminating water systems until disaster strikes.

Sewage is a perfect home to many microorganisms, including many pathogens. Although microorganisms are relatively easy to treat in a well-situated decentralized system, the risk of pathogens is typically the biggest concern in decentralized systems. Many diseases can be carried by sewage contaminated waters. Typhoid and Cholera (bacteria), Gastroenteritis (caused by viruses) Amoebic Dysentery, Giardiasis (caused by parasitic protozoans), and intestinal roundworm (Helminth) can all contaminate drinking water supplies. (See Table 3, page 8.)

Properly functioning systems are very effective at pathogen removal, removing almost all fecal coliform bacteria and removing 99.9 percent or more of the viruses (Siegrist 2001). Because even 0.01 percent of viruses can still cause infections, proper siting and isolation of systems is critical to preserve public health.

Unfortunately, most communities do not pay enough attention to the health risk of sewage contaminating water systems until disaster strikes. The contamination of municipal drinking water wells in Walkerton, Ontario, in May 2000 by a particularly virulent strain of Escherichia coli (E. coli O157:H7) and by Campylobacter jejuni, which killed seven people and sickened 2,300, dramatically highlighted the possibility that even countries with modern water systems can still be vulnerable to sewage contaminations (O'Connor 2002). In Walkerton, as is more common in the developed world, the contaminated runoff came from cattle, not humans, but human sewage certainly has been the source for even worse epidemics.

Biochemical oxygen demand (BOD) is a measure of the amount of oxygen consumed when natural biological and chemical systems treat a pollutant. Oxygen consumed to treat the waste is not available to fish and other parts of the natural ecosystem. BOD is one of the major pollutants, however, from direct surface discharges, such as sewage treatment plants, package treatment plants, and decentralized wastewater treatment systems that leak into surface water. BOD from dissolved and suspended solids in sewage is rarely a problem for decentralized soil-based systems. Decentralized systems can, however, create discharges that rapidly reduce oxygen levels if sewage-laden waters leak into surface waters.

In addition to organic materials, any imaginable liquid or slurry can and probably has been flushed down a toilet or poured down a drain into sewage disposal systems. Heavy metals, (e.g., mercury), hydrocarbons (e.g., used motor oil), and millions of man-made organic compounds have contaminated ground and surface water. Decentralized treatment systems typically provide very little treatment for these compounds. Such compounds may also kill the natural biota, which are a critical part of a functioning decentralized system.

SOILS: THE CORE OF DECENTRALIZED WASTEWATER TREATMENT

Decentralized wastewater treatment systems are about disposing of and treating sewage. The latter part of this equation, treatment, is regrettably often given short shrift. One of the authors of this PAS Report (Feiden) was once involved with cleaning up the mess left behind by an engineer who

TABLE 3. PRINCIPAL SEWAGE (HUMAN AND ANIMALS) PATHOGENS

Pathogens	Type of Pathogen	Associated Disease	Typical Survival Time (in days)*	
			In Sewage	Unsaturated Soils
Salmonella typhi	Bacteria	Typhoid fever (fever, diarrhea, small intestine ulcers)	Maximum <60 Typical <30	Maximum <70 Typical <20
Salmonella enteritidis and other Salmonella	Bacteria	Salmonellosis (diarrhea and gastrointestinal)	Maximum <60 Typical <30	Maximum <70 Typical <20
Escherichia (E) coli (0157:H7)	Bacteria	Hemorrhagic colitis (severe diarrhea and gastrointestinal) Most E. coli strains harmless.	Maximum <60 Typical <30	Maximum <70 Typical <20
Campylobacter jejuni	Bacteria	Campylocateriosis (diarrhea, acute gastroenteritis)		
Clostridium perfringens	Bacteria	Acute Gastroenteritis		
Legionella pheumophila	Bacteria	Legionellosis (respiratory)		
Leptospira	Bacteria	Leptospirosis (jaundice, fever)		
Listeria	Bacteria	Listeriosis and relatd (flu-like)		
Shigella	Bacteria	Shigellosis or bacillary dysentery (gastrointenstinal)	Maximum <30 Typical <10	
Vibrio cholarae	Bacteria	Cholera (extreme diarrhea, gastrointestinal illness, dehydration)		
Rotavirus, reovirus, adenovirus, calicivirus, astrovirus, Nowalk virus, Norovirus	Virus	Viral Gastroenteritis		
Enteroviruses, including polioviruses, coxsackieviruses, and echoviruses	Virus	Mild upper respiratory, flu-like illness, rashes. Rarely, viral meningitis, myocarditis, encephalitis and others.	Maximum <120 Typical <50	Maximum <100 Typical <20
Hepatitis A	Virus	Hepatitis A		
Balantidium coli	Protozoan Parasite	Balantidiasia (Diarrhea and occasionally dysentery)		
Cryptosporidium parvum	Protozoan Parasite	Cryptosporidiosis (diarrhea, gastrointestinal illness)		
Entamoeba histolytica	Protozoan Parasite	Amebiasis (Amoebic Dysentery, diarrhea)	Maximum <30 Typical <15	Maximum <20 Typical <10
Giardia intestinalis	Protozoan Parasite	Giarida (diarrhea and gastrointestinal)		
Naegleria fowleri	Protozoan Parasite	Amebic Menigoencephalitis (inflammation of the brain)		
Ascaris lumbricoides	Helminth Worms	Intestinal roundworm (abdominal pain	Many months	Many months
Ancylostoma duodenale, Necator americanus	Helminth Worms	Hookworm (diarrhea or cramps and anemia)		Maximum <900 Typical <30

*Survival time is highly variable depending on temperature, moisture, salinity, sunlight, and other factors.
Source: Centers for Disease Control 2005 and Westcot 1997

was brilliant at making sure that decentralized systems did not fail at the surface of the ground. The engineer worked to ensure adequate elevation difference (head) to push wastewater into the ground, so that his systems effectively became groundwater injection systems, good at sewage disposal, but not so good at sewage treatment.

The heart of most decentralized wastewater treatment systems is the native soil and its incredibility vibrant biota—naturally occurring soil organisms. In a conventional system, the native soil is the natural reactor that ultimately accepts wastewater. Native soil is the soil left on site from natural soil formation processes, whether that soil was left 12,000 years ago by receding glaciers, deposited by wind-blown sediments, or created by on-site weathering of bedrock or lava flows. With some exceptions, such as some lava-formed soils in Hawaii, some shoreline sand depositions, and some alluvial fans, these soils typically have been worked by many thousands of years of soil formation processes. These processes tend to create a structure and a biota often better suited for sewage disposal than soil or other material manufactured or trucked onto a site.

Some innovative and alternative systems function without natural soil, whether they are composting toilets or micro-treatment plants with direct surface discharge. The vast majority of systems use soil, however, either for all post-septic tank treatment or for final treatment (polishing) of water discharged from innovative and alternative systems.

When conditions are appropriate, natural in-situ soil, with its biota, provides a far more cost-effective, and often more effective overall treatment system than artificial media and components. This is especially true of the naturally occurring soils within the upper portion of the soil profile.

Naturally occurring soils can have extremely robust biological, chemical, and physical treatment processes to treat pollutants. The soil is full of microorganisms that thrive on many of the worst biological and nutrient contaminates in soil. Soil and other media physically filter pollutants and nutrients as they pass by. Soil and other media provide for th e absorption of pollutants and nutrients, whereby those pollutants adhere to the surface of the soil. Chemical processes in the soil, water, and air can all transform many pollutants into inert or beneficial materials. (See Table 4.)

TABLE 4. MEASURES OF SOIL FOR DECENTRALIZED WASTEWATER TREATMENT

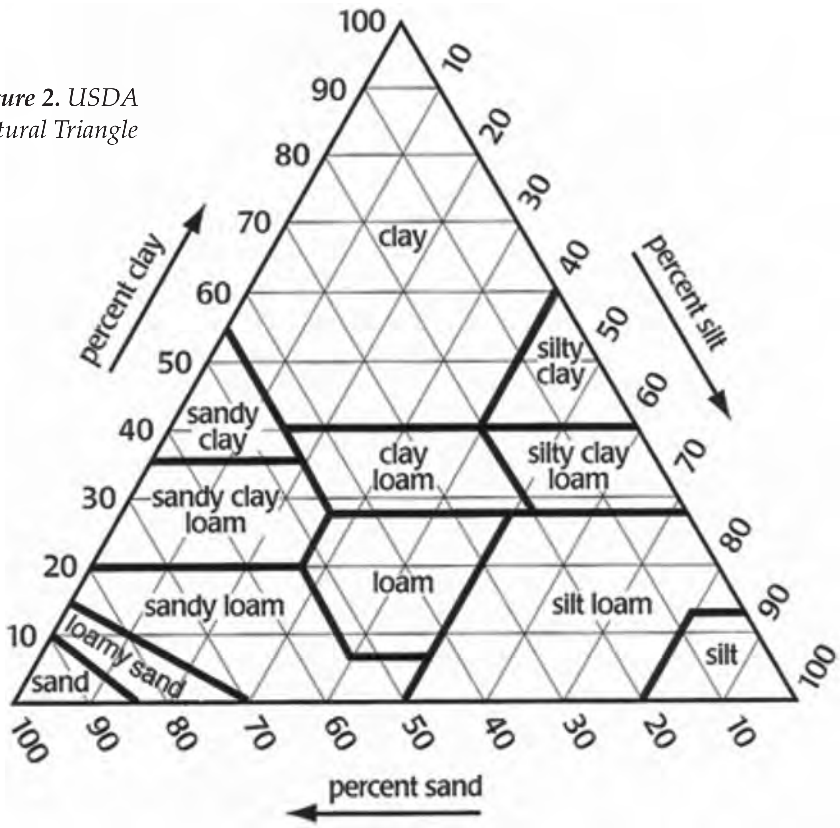
Soil Factor	Categories			Relevance to Sewage Disposal
Texture	Proportions of different soil particle size as:			
	Sand	2.00-0.05 mm USDA	2.00-0.02 mm International	It is easier to move water through larger particles in unsaturated flows, but smaller particles provide better treatment ***if*** permeability is adequate and ***if*** unsaturated flows exist.
	Silt	0.05-0.002 mm USDA	0.02-0.002 mm International	
	Clay	<0.002 mm USDA	<0.002 mm International	
Structure	Grouping of soil into peds (natural aggregates of soil that tend to stay attached)			Soil structure that provides moderate permeability while maximizing wastewater/soil interaction provides the best treatment (e.g., subangular blocky structure). Structure is often more important than texture.
	Granular	Connected grains		
	Blocky	Blocks oriented horizontally and vertically		
	Columnar	Column oriented vertically		
	Platey	Horizontal plates		
	Single grain	Each grain (sand) not connected (no structure)		
	Massive	Solid hardpan (no structure)		
Limiting layer and restrictive horizon	Depth to impermeable layer, groundwater, or ledge			Depth of leachfield to limiting layer determines how much soil is available to treat wastewater
Redoximorphic features	Evidence of groundwater levels (reduced shows soil typically inundated, "redox" shows seasonal high groundwater)			Once wastewater enters groundwater there is very little treatment
Soil consistency	Measures resistance to penetration (e.g., loose, friable, firm, extremely firm)			Firm and extremely firm soil may be difficult to move wastewater through under unsaturated conditions
Hydraulic conductivity or permeability	Ability to move water through the soil. (The often-used percolation test measures water moving into, not through, the soil.)			Critical for determining the size of a system. Determining soils from a test pit can be more accurate than a 'perc" test.

Source: Centers for Disease Control 2005 and Westcot 1997

In order for soil conditions to be appropriate, however, the right combination of soil attributes must exist. Sand, silt, and clay are simply defined by soil particle size. The percentage of each particle size defines the soil texture of a given soil (see Figure 2). But analysts must take many critical factors into account to judge soil suitability:

- Soil texture (percentage of sand, silt and clay)
- Soil structure (the way the soil particles connect to each other)
- Soil moisture and groundwater levels (unsaturated conditions are best)
- Depth of soil to ledge (the amount of soil above bedrock)
- Other limiting layers (such as very dense layers)
- Location of the soil on the landscape
- Distance to sensitive environmental receptors (such as water supplies, streams, wetlands)

Figure 2. *USDA Textural Triangle*



Source: NASA Goddard Space Flight Center

Many jurisdictions use percolation tests, designed to measure the rate at which water enters the soil, as a measure of the ability of soil to move and treat wastewater. The percolation rate is determined by digging a hole in the ground of a set diameter, pre-soaking it to partially mimic field conditions, and then measuring how long it takes for the water level to drop an inch (hence the test results are given in minutes per inch). Sands typically have percolation rates faster than two minutes per inch, denser soils have much slower rates. Most states using the percolation test consider soils with percolation rates of 60 minutes per inch or faster as suitable for on-site sewage disposal systems. Soils that have very slow percolation rates ("tight soils"), which typically have high concentrations of clay or silt, may limit the ability of effluent to enter and flow through the ground with unsaturated flows. The percolation test was designed to limit the use of these soils and to mitigate the use of marginal soils.

The percolation rate, however, is often not an accurate predictor of the soils permeability (how water and effluent move within the soil profile). Experienced designers can manipulate the percolation test to improve their results, by scarifying the hole, loosing rocks within the hole, and testing during periods of low soil moisture. Even without manipulations, percolation test results can be highly variable, especially on soils such as glacial tills, which can vary significantly in composition over very short distances. Arguably, a percolation test is a less accurate and more expensive method of measuring the ability of soil to provide adequate decentralized sewage treatment than a qualified, and honest, professional simply inspecting the soil to determine for soil texture and structure, seasonally high groundwater, and landscape position. An increasing number of states no longer use the percolation test as the sole measure of determining the size of a system (Gross et al. 1988), and many jurisdictions no longer require the percolation test at all. These jurisdictions (e.g., Maine and Wisconsin) rely on competent professionals inspecting, feeling, manipulating, and logging-in soil conditions in-situ.

For example, one can distinguish between the ratio of sand, silt, and clay, measures of soil texture, using simple hand tests Take a sample of soil, wet it, if you can't even make a ball, you have sand. If you can make a ball, roll it in your hands into a ribbon. The longer the ribbon you can make, the more you move from sand loam to silt to clay. Obviously, soil evaluators with more experience can make the most accurate determinations.

To demonstrate this, at the risk of oversimplifying, take soil and mix it in water in a jar. Shake the jar. The soil that settles within minutes is mostly sand. The soil that settles within a few hours is mostly silt. The soil that takes days and weeks to settle is mostly clay.

Figure 3 shows different methods of determining soil conditions. A backhoe test pit allows a soil evaluator to very carefully and in conformance with Occupational Health and Safety Administration (OSHA) regulations inspect soil conditions in place. It is easiest to examine the soil profile in place to determine soil texture, soil structure, seasonal high and permanent groundwater levels, ledge, and other limiting factors. A percolation test allows the measurement of how quickly water enters a presoaked hole.

Some soils are ideal for decentralized sewage treatment, and some soils are inappropriate for decentralized sewage treatment. Most soils and sites fall somewhere between these extremes. Many sites are not appropriate for any type of decentralized wastewater treatment system and may be undevelopable without a centralized wastewater treatment facility or a community package plant.

THEORY OF TREATMENT

A properly functioning decentralized wastewater treatment system must provide both adequate *treatment* and *disposal* of sewage. Historically, the primary function of decentralized systems was to eliminate pathogens and dispose of sewage to ensure that it did not break out onto the ground nor backup to the house or business that generated the waste. The first public efforts to control sewage emphasized this approach. (For example, the percolation test, invented by Henry Ryon at the turn of the twentieth century, was designed to measure how quickly sewage could be applied to the ground, not to measure any rate of treatment.)

Photos by Wayne Feiden

Figure 3: *Backhoe test hole, percolation test, and regulatory witness.*

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Figure 4. *Algal growth on a lake from improper decentralized sewage treatment.*

Because of environmental and public health concerns, most regulations today emphasize the need to treat sewage before it reaches the groundwater or surface water. (Figure 4 shows improperly treated sewage reaching a lake.) The old focus on disposal, however, is still apparent in many jurisdictions, as evidenced by the fact that most regulations typically make it easier to discharge sewage into sands and gravels than into other types of soils, yet sands and gravels provide the least treatment.

The most effective and least expensive decentralized sewage systems use natural systems, especially in soil, or mimic those systems, in soil and artificial media, when natural soil-based systems are not practical. Systems that take advantage of natural microorganisms for treatment use natural chemical and physical treatment processes, effectively disperse untreatable pollutants, and are sensitive to natural environmental limitations. These systems can also lower the cost of sewage disposal. In many communities, the cost of systems can become a major impediment to development, especially of affordable housing. Systems that can provide cost-effective treatment are especially in demand.

The following features are the most important in developing effective treatment systems:

- *Provide an opportunity for treatment.* Every system incorporates some type of physical and chemical filtering and biological activity. In an in-ground system, most of this treatment occurs between the sewage discharge point (the leach lines) and the groundwater.

- *Maximize interaction between sewage disposal and the most active biological zone*. In an in-ground system (as opposed to systems with artificial or natural materials in a controlled reactor), this typically means maximizing interaction with native soils above the groundwater. Biological treatment is the single most important aspect of decentralized sewage treatment.

- *Reduce groundwater mounding under the system*. In most systems, this means controlling discharge rates so the sheer volume of sewage being discharged in any one place does not overwhelm the capacity of the ground between the system and groundwater to effectively treat and dispose of the sewage and does not lead to groundwater levels rising under the system.

- *Provide dilution of sewage discharge*. The dark secret of conventional in-ground decentralized wastewater treatment is that nitrogen treatment is almost nonexistent, so that dilution becomes critical. (As mentioned above, the old adage that the solution to pollution is dilution, an approach often ridiculed, holds true more often then we like to admit.) The wider effluent is spread out on a site, the greater the mixing and dilution between the effluent, rainwater, and groundwater. Certain kinds of systems use very low loading rates over very large areas (e.g., drip irrigation and low

CONVENTIONAL DECENTRALIZED WASTEWATER TREATMENT SYSTEMS (SEPTIC SYSTEMS)

Conventional in-ground wastewater treatment systems rely on native soil for most of the sewage treatment. Because constructed components are few and simple, these systems are relatively inexpensive and their operation is relatively easy. When soil conditions are appropriate, conventional systems can provide superb treatment. When soil conditions are not appropriate, conventional systems can be nothing more then groundwater injection of contaminated sewage.

TABLE 5. STEPS FOR IMPROVED DESIGN

Design Step	Interaction with active biological zone	Provide opportunity for treatment	Reduce groundwater mounding	Dilution (especially for Nitrogen)
Vertical distance to groundwater	✓	✓	✓	✓
Vertical distance to ledge	✓	✓	✓	✓
Permeable soils (percolation rate)		✓	✓	
Distance from environmental receptors		✓		
Distance from discharge points (e.g. drains)		✓		
Long and thin system design	✓	✓	✓	✓
Leachfield parallel with contours	✓	✓	✓	✓
Shallow leach-field	✓	✓	✓	✓
Even distribution of effluent	✓	✓	✓	✓

A "typical" conventional in-ground system starts with a building sewer extending from the building where waste is generated to a septic tank (labeled "a" in Figure 5). Inlet and outlet baffles (labeled "b" in Figure 5) in the septic tank catch solids (sludge) and greases. A solid pipe then carries effluent to a distribution box (labeled "c" in Figure 5). The distribution box is designed so that effluent is distributed somewhat evenly to the leachfield (labeled "d" in Figure 5). Inside the leachfield, perforated pipe allows effluent to drain into clean stone, and from clean stone into the soil.

Although some limited treatment occurs in the septic tank, its primary function is to allow solids and greases to settle. Septic tanks are typically large enough that a droplet of wastewater sits in the tank for a mean time of at least 48 hours, allowing the heavier solids (sludge) to settle to the bottom and the lighter greases to float to the top. The baffles in the tank are designed to prevent these materials from moving beyond the tank.

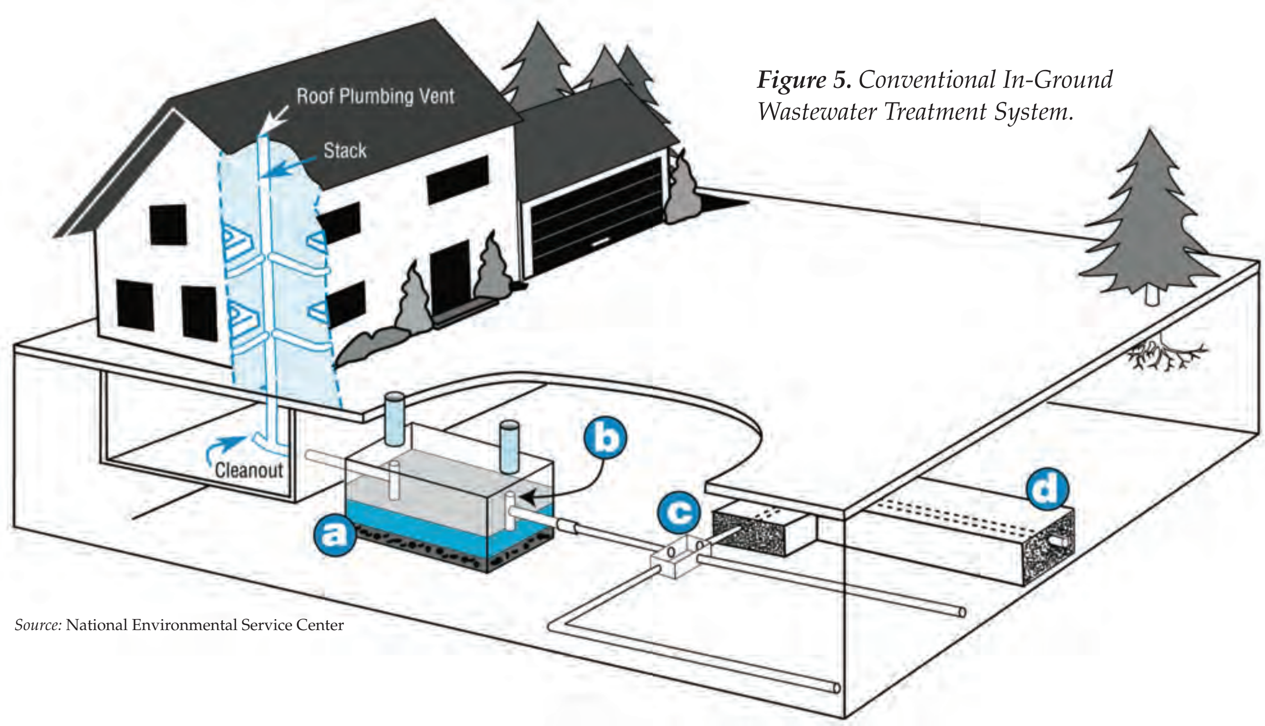


Figure 5. *Conventional In-Ground Wastewater Treatment System.*

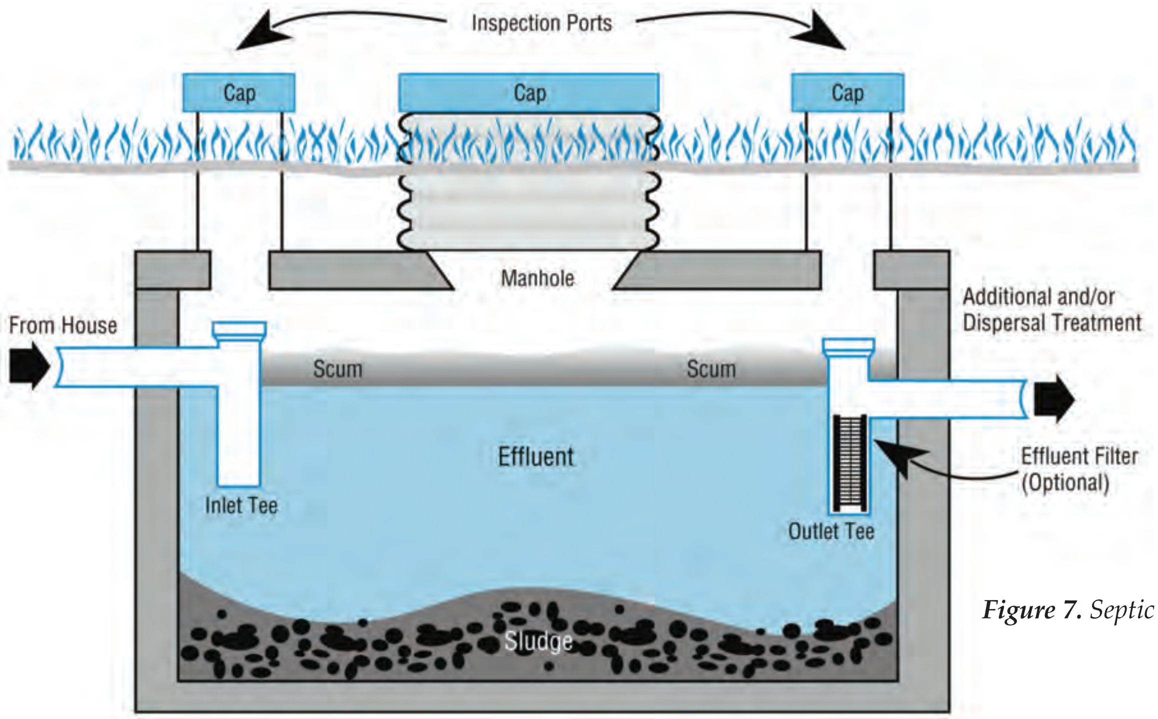
Source: National Environmental Service Center

The septic tank is typically a large concrete (see Figures 6 and 7), plastic, or fiberglass tank. So long as the tanks are maintained property and the wastewater has sufficient residence time in the tank, the septic tank provides adequate primary treatment. The tank is so oxygen poor that treatment beyond settling and floatation is relatively limited. (The oxygen poor environment is the reason for the terms "septic tank" and "septic system.")

In a conventional in-ground system, sewage leaving the septic tank gets discharged into a leachfield. Typically, the leachfield is shaped as a series of narrow trenches (from six inches up to several feet wide) or a wider bed. The field is filled with small diameter stone or some type of concrete or plastic chambers. Effluent is distributed into the chamber or through perforated pipes within the stone (see "d" in Figure 5). The effluent drains through the stone or chambers and enters the soil at the bottom of the field. Treatment and movement of effluent is almost identical whether the leachfield is filled with stone or plastic chambers.

Figure 6. *Bottom half of a concrete septic tank.*

State of Vermont



Source: National Environmental Service Center

Figure 7. *Septic Tank*

Effluent draining into a leachfield is rich in organic and inorganic materials. Within a few months of use, a new leachfield develops a biological mat, or biomat, sometimes referred to as a clogging mat. The biomat forms at the interface between the stone and the soil and generally at any place where there is a change in pore size. Organic material and inorganic material is deposited at the biological mat, where, under aerobic conditions, large numbers of microorganisms will congregate to feed on the organic material.

The biomat has the effect of slowing down the permeability of the soil, reducing its ability to accept large concentrations of effluent. More importantly, however, the biomat creates an area for healthy biological activity and forces effluent to spread out over the entire leachfield, reducing the risks of short-circuiting of effluent into the groundwater that otherwise could exist.

Conventional systems, when properly sited in appropriate soils, can remove most microorganisms, biochemical oxygen demand, and phosphorus, and allow the opportunity for nitrogen dilution to acceptable levels. Because these systems need certain dry soils, the search for adequate soil can drive the location and land consumption of development over any other planning goals.

In a conventional in-ground system, the leachfield is a network of perforated pipes set in clean stone or some other type of media (e.g. cut-up tires; see McKenzie 2003) placed in an excavation within the native soil. In some jurisdictions, some native soil may be removed and replaced with sand if the native soil has a very slow permeability rate. Most jurisdictions have moved away from this approach because it tends to replace the biologically rich native soil with a media usually much less active biologically.

Some jurisdictions allow holding tanks (sometimes referred to as tight tanks) when no other system is possible, although generally only for an existing facility with a failed system. A septage hauler pumps these sealed tanks out every time they fill up. Except for some limited seasonal dwellings, the cost of constantly pumping out these facilities is very high. The cost is high enough that many users are tempted to sneak in a small leachfield to avoid pumping out the tank.

INNOVATIVE AND ALTERNATIVE DECENTRALIZED WASTEWATER TREATMENT SYSTEMS

Innovative and alternative (I&A) systems can work on many, but not all, sites not appropriate for conventional systems due to inadequate soils or other site limitations. A wide variety of proprietary "black box" systems are designed to work as mini-sewage treatment plants. More common, however, are I&A systems that mimic natural treatment systems by using imported media and reactors. (A reactor is any system where treatment activity takes place, whether in natural systems or built systems.)

Health, sanitary, and sewage disposal regulations, however, should never replace good planning and growth management controls.

I&A systems use imported soils (typically sand) or artificial man-made materials as a fixed filter to provide physical, chemical, and biological treatment over and above what native soils can provide. They also typically use pumps to distribute effluent efficiently, maximizing treatment potential at the filtering site. Finally, most I&A systems can recognize and react to the presence of saturated and unsaturated conditions to ensure flows allowing the most efficient treatment of sewage, something difficult to do in an in-ground system. Several of the more common I&A systems are described in greater depth below.

While most I&A systems are initially more expensive than conventional systems to install, their efficiencies and superior treatment can make them more cost-effective than centralized treatment over the long run. As technology improves and the profit available from creating a building lot increases, communities that rely on sewage regulations to limit development in inappropriate locations and to avoid unreasonable loads of their infrastructure will find that developers will approach them with new treatment options and promises of adequate treatment that do not put additional burdens on the community's sewerage system.

Health, sanitary, and sewage disposal regulations, however, should never replace good planning and growth management controls. Although many sites will remain economically unviable for development because of site constraints, a community should always ensure that its development controls are adequate to meet the goals it sets for protection of its residents, natural resources, and infrastructure investments. Developers could make all site limitations as they are currently defined in a community's regulations seem to disappear through new technology that may or may not treat effluent in a way that truly meets the health and siting standards and does not add to the burden on the community's sewerage system. It is important for planners to understand what innovative and alternative technologies are out there to allow them to plan for this eventuality.

I&A systems typically require some type of pressurized dosing system. In a pressurized system, a pump, or sometimes a siphon, sends a large volume of effluent under pressureto the treatment system. Pressure distribution dramatically improves the treatment capabilities of many systems because it ensures the entire system is used (in many conventional system, portions of the system never receive wastewater while other portions of the system are overloaded). Pressure distribution can also allow the designer to plan for optimal flows and resting periods as well as to manage the amount of flow depending on the level of soil saturation, which influences how much effluent can be adequately accommodated.

Pressurized systems can make some designers and regulators nervous because they require a thorough understanding of pressure design and a balance of pressures great enough to prevent clogging and small enough to minimize friction losses (explained in the following sentence), while still ensuring even distribution for treatment throughout the system. Clogging occurs when pressure is too little to prevent the build up of solids or algae at choke points in the system. Friction loss occurs when flows increase, often to prevent clogging, forcing effluent at high rates of flow down narrow pipes and creating turbulent flow conditions, making even distribution difficult. With a bit of practice, however, these systems are relatively simple to design, especially with computer-aided design and related software (Winkler and Feiden 1997). (See Figures 8 and 9.)

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Figure 8. *Pressure testing a low-pressure pressure distribution system (pressurized mound).*

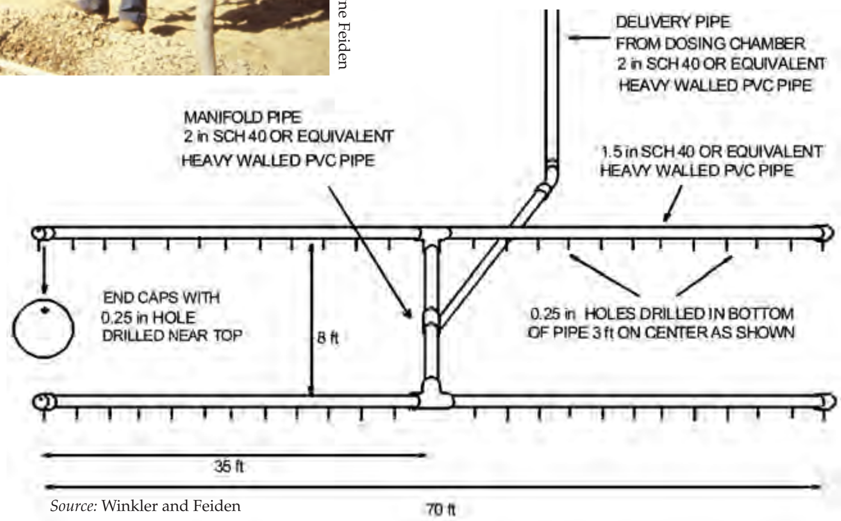

Figure 9. *Typical Pressure Design Layout.*

Source: Winkler and Feiden

In a conventional system, distribution boxes and tees are used to improve the effectiveness of effluent distribution. In a distribution box, effluent flows from a septic tank into a simple, level, small concrete or plastic box (Figure 10). By keeping the outlet pipes at the same height, the distribution box can improve the likelihood that multiple sections of a leachfield receive the same amount of effluent, as long as the box remains level over time. In a tee, the pipe coming from the septic tank enters a tee and the flow is split in half to achieve even distribution in the leachfield.

Unfortunately, in a conventional system, gravity effluent distribution does not provide anything like uniform distribution. Distribution boxes and tees and outlet pipes do not remain level, and turbulent flows into the boxes and tees prevent their proper operation. As a result, gravity distribution can create local overloading, which can lead to premature system failure and short-circuiting of effluent into cracks in the soil, root channels, and into highly permeable sands and gravels, thus increasing the likelihood of groundwater contamination. The natural development of an organic mat (or clogging layer) when leachfields mature, after a few months of use, reduces, but does not eliminate, the problems with local overloading and short-circuiting.

While regulators and property owners often worry about tight soils and silt and clay soils, these soils can actually provide more effective treatment

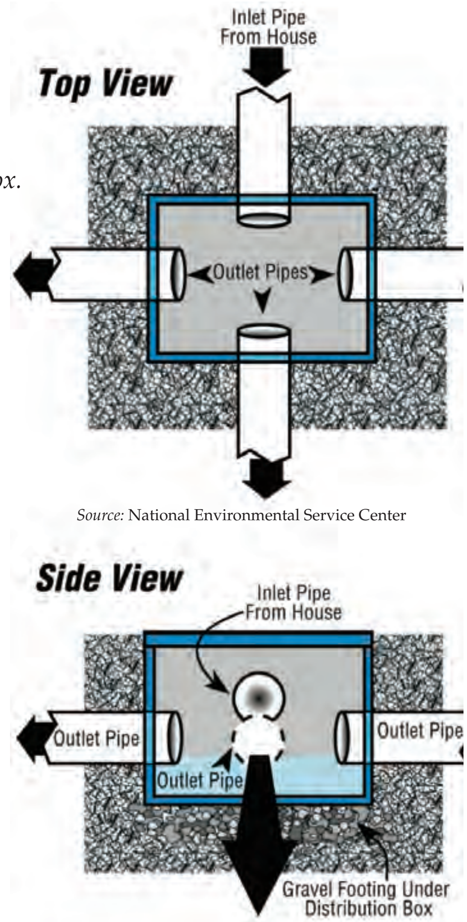

Figure 10. *Distribution Box.*

Source: National Environmental Service Center

than sands ***if*** *only* the soils have adequate permeability to move effluent through the soil matrix and adequate depth to groundwater to remove contaminants. The most difficult soils in which to treat wastewater are sands and gravels, which can allow effluent to move so quickly through the sand column that little treatment occurs.

Composting toilets are one of the best-known current alternative systems (Figure 11). These waterless toilets remove most of the water from toilet waste and dramatically reduce the volume of the waste product. In proper situations with well-functioning toilets, the composting process and temperature can kill most of the pathogens in the sewage, although the risk that some pathogens will remain always exists. The low volume of dry compost that remains is ultimately disposed of either in land application or at a landfill. These toilets vary from small toilets, often found in camps, in which electricity is used to assist in the composting (in some cases, through simple dehydration) to

BENEFITS OF PRESSURIZED UNIFORM DISTRIBUTION (PUMPS OF SIPHONS)

- Move effluent effectively (especially important for more complicated innovative and alternative systems)
- Use the leach field more effectively, potentially allowing for a smaller leachfield
- Provide effective treatment in sands, gravels, and excessively permeable soils, thereby minimizing groundwater contamination
- Reduce premature clogging in the leachfield, especially in slowly permeable soils and in soils with massive structure (e.g., sand filters, mound systems, and other filled systems)
- Provide limited nitrogen treatment, especially in nitrogen-sensitive areas such as in coastal areas. (Generally, it is desireable to avoid anaerobic conditions, but the very short anaerobic flooding cycle that is often part of a pumped system followed by aerobic treatment can enhance nitrogen reduction.)

larger models, often found in the backcountry and in commercial applications that truly compost most of the toilet waste. Except for backcountry and camp applications, where there is no running water, gray-water systems are still needed to treat all other domestic water. Because gray water can still contain high concentrations of contaminates, including pathogens, the gray-water systems typically have the same siting constraints as conventional black-water systems (National Association of Plumbing-Heating-Cooling Contractors 1992).

Pressurized mound systems and sand filters both use a sand media to pretreat septic tank effluent before discharging it, typically into the native soil. Effluent flows from the residence or commercial facility into a septic tank and from there into a pumping or siphon chamber. The pump or siphon periodically doses effluent, under low pressure, into a leachfield within sand (Figure 12) or sprayed on top of a sand bed. In a sand filter, the effluent

Figure 11. *Alternative composting toilet in Sequoia/ Kings Canyon, California.*

goes through the sand and then is discharged, usually into a conventional in-ground leachfield (although a few states allow direct discharge). In a once-pass sand filter, wastewater passes once through the filter. More common, however, is the recirculating sand filter, in which the average wastewater droplet moves through the filter several times before being discharged. In a pressurized mound system, the sand is in a mound built above native soil, so that wastewater is treated first in the sand and then discharged from the bottom of the sand mound into the soil, where additional treatment is provided. Both systems provide some nitrogen reduction (especially sand filters) and excellent pathogen reduction.

Qualified professionals typically find it easy to design both sand filters (in their many varieties of buried sand filters, once-pass sand filters, and recirculating sand filters) and pressurized mounds (see Figure 13), but contractors may find them more complicated than the systems normally used for sewage treatment. Although many of the patented components on the market are designed to make installation easier (e.g. pre-wired pumping chambers, sewage effluent pumps, and sand filter components), the basic design of these devices is not patented and can be described in detail in sewage disposal regulations.

Constructed or artificial wetlands are wetlands built to provide a treatment system. Natural wetlands are incredibly effective at physically, chemically, and biologically filtering water. The idea of constructed wetlands is to mimic

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Figure 12. *Siphon-fed pressurized mound system, Vermont.*

these features, without adding pollutants to natural wetlands. Constructed wetlands are commonly used for polishing of effluent (e.g., treating effluent after it has passed through a sand filter) in decentralized systems, as well as for tertiary treatment at centralized treatment facilities, leachate treatment, and stormwater treatment (EPA 1993a, EPA 1993b).

Constructed wetlands have been used for many years in the southern U.S. and in Europe, and are growing in popularity in more northern U.S. climates. They are one of the most common forms of alternative decentralized sewage treatment and disposal. For example, when one of the authors of this paper was doing research on decentralized wastewater treatment in Hungary, constructed wetlands were the primary alternative to conventional soil disposal systems (Feiden 1996.)

There are many other types of innovative and alternative systems. Unlike sand filters and pressurized mound systems, many of these systems are proprietary systems and, given that the technology is constantly evolving, these systems are harder to evaluate. Many of the technologies are excellent, although some of them are unproven, expensive, and extremely complicated. (See Table 6.) Generally, these technologies all involve taking effluent from a septic tank and pumping it under low pressure, either in periodic does or in continuous trickle. Many of these technologies discharge pressurized effluent into a fixed film reactor (any treatment system where treatment occurs when effluent flows through a media), such as sand or some type of artificial media. Artificial media can be almost any inert media with a large surface area to volume ratio, from foam blocks (see Figure 14) to chopped-up tires (McKenzie 2003, Grimes et al. 2003).

Many of the most innovative and alternative systems are experimental or prototype systems without wide adoption.

Some of these systems are most appropriate for large-scale community systems if not centralized treatment systems. Biogas systems and composting systems, for example, are already being used extensively for large-scale animal farms in China, the U.S., and elsewhere. In biogas systems, animal manure is digested under anaerobic conditions to produce combustible biogas. In a composting system, manure is composted into a product that can be applied to a field. Temperatures in these processes are typically high enough to kill pathogens. Human waste has been digested into biogas when the waste is removed directly from a latrine (for example, in many small-scale operations in China) and from sewage sludge removed from centralized wastewater treatment facilities. Given the volumes of water added to domestic and commercial wastewater flows, these systems could work for human sewage only by employing large-scale dewatering processes.

TABLE 6. DECENTRALIZED WASTEWATER TREATMENT TECHNOLOGY SUMMARY

System Type	Summary	Benefits	Disadvantages
Composting toilet	Toilet composts sewage without water. Some models use supplemental external heat source.	Simple to install. Inexpensive for camps without water.	Low user acceptance. Greywater, which is also highly contaminated, must be treated separately.
Conventional soil-based bed and trench	Septic tank drains into perforated pipe set in stone, a chamber, or other media and drains into soil	Simple, inexpensive, and effective, when properly sited, designed, and built.	Does not work under many site conditions and can pollute if incorrectly used. Does not remove nitrogen
Low Pressure Pipe (LPP) Wastewater System	Effluent is dosed under low pressure to a small diameter perforated pipe located within a very narrow, and often very shallow, in-ground trench.	Less expensive than most alternative systems. LPPs take advantage of pressure design and native soils and work on more sites then conventional systems.	Does not work under all soil conditions. More difficult design, installation, and maintenance.
Drip Irrigation or Trickle System	Effluent is distributed under low pressure at shallow depth through small diameter pipes throughout a large area	Less expensive than most alternative systems. Drip systems take advantage of pressure design and native soils and work on more sites then conventional systems. Minimum disturbance of site.	Does not work under all soil conditions. More difficult design, installation, and maintenance.
Pressurized Mound or "Wisconsin" Mound	Septic tank drains to a pumping chamber, which doses under low pressure to a small diameter, perforated pipe located in a bed within a built-up sand mound placed on top of plowed native soil.	Pressure distribution provides effective use of system and improved treatment. Very effective on a wider range of soil conditions than a conventional system, especially soils shallow to some type of limiting condition. Limited Nitrogen treatment.	Does not work under all soil conditions. More difficult design, installation, and maintenance. Can be expensive and land extensive.
Sand filter (intermittent, recirculating, and trickling)	Septic tank drains to a pumping chamber, which doses under low pressure to a bed of sand and then drains (sometimes after recirculating more than once) to a conventional system.	Enhances treatment of pollutants, including nitrogen. Very effective as a pre-treatment unit. Useful in difficult soil conditions.	Treats sewage but generally still requires final soil disposal (although some jurisdictions allow direct discharge). Can be expensive and complicated.
Other artificial media/fixed filter systems. Includes trickling filters and a wide variety of proprietary technologies.	A range of dosing and trickling systems using a range of artificial and natural medias	Can provide excellent treatment or pretreatment. Can work in a large variety of sites	Can be very expensive and complicated to design, install, and maintain. Performance can be uneven, especially for small applications.
Constructed or artificial wetlands	Pretreated effluent is discharged into an artificial wetland before ultimate discharge	Can be highly effective at treating effluent. More commonly used in the southern U.S. and in Europe.	Can be very expensive and complicated to design, install, and maintain. Not practical for small applications. Less reliable in cold climates.
Evapotranspiration (ET)	Effluent is discharged to a leach field sealed from groundwater. Effluent removed through combination of evaporation and plant uptake (transpiration).	Can be highly effective at treating effluent. Requires arid climates or a greenhouse.	Can be very expensive and complicated to design, install, and maintain. Often difficult for small applications. Less reliable in humid and wet climates.

Source: EPA 2002, NAHB Research Center 2003, and the authors. See Crites and Tchobanoglous 1998, Winkler and Feiden 2001, and U.S. EPA generally for more information on conventional and alternative.

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Figure 13. A sand-filled mound system dominating the yard in Hatfield, Massachusetts.

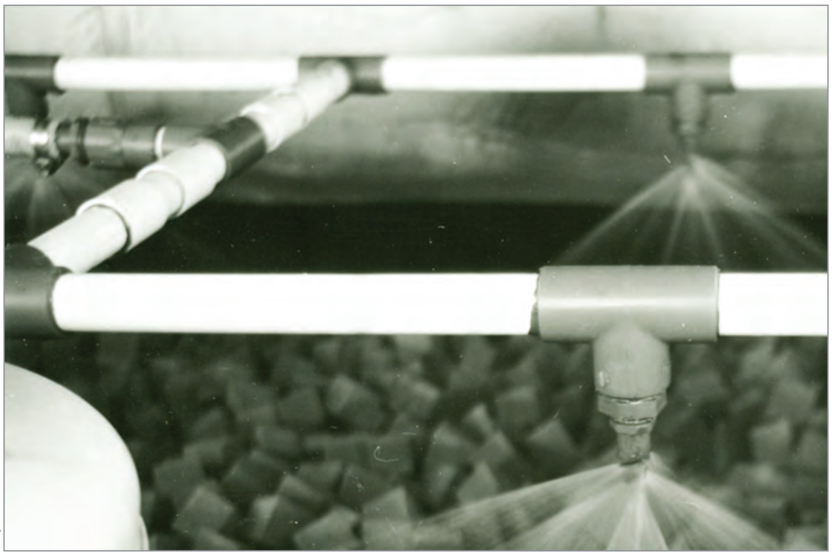

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Figure 14. Trickling filter, artificial fixed film media; system in Gloucester, Massachusetts.

REGULATORY MODELS

Regulations for decentralized wastewater treatment systems can be either prescriptive or performance based. Prescriptive regulations are a cookbook of how to site and design to comply with the regulations and receive a permit. The public often likes the clarity of prescriptive regulations, while hating the inherent lack of flexibility in such an approach at the same time. Performance regulations, on the other hand, provide a standard for disposal and treatment and leave it up to the public to determine the best way to meet that standard.

Although regulations vary widely from jurisdiction to jurisdiction, in the decentralized wastewater treatment world, regulations for small projects tend to be prescriptive based and regulations for large projects tend to be performance based. Because decentralized wastewater regulations are generally set by the state or local government, standard thresholds for prescriptive and performance regulations vary. Federal National Pollution Discharge Elimination System (NPDES) permits are required only for direct discharges into a water body, such as from centralized sewage treatment facilities or package treatment plants.

Small projects tend to be regulated with a prescriptive-based approach because the engineering design costs, evaluation, monitoring, and follow-up required for a performance-based approach are too large for a small project to carry. (See the discussion of management below.) Large projects tend to be regulated with a performance-based approach because it provides the community with greater assurance that discharges will meet standards for disposal and treatment as well as providing greater flexibility in design of those projects.

The obvious problem with any prescriptive-based approach is that it stifles creativity and often cuts off the possibility of using "soft" management-based approaches, such as regularly pumping septic tanks to improve performance. The problem with performance-based approaches is that they sometimes do not deliver as promised, and because performance-based approaches often rely on private monitoring, system owners may not correct poorly operating systems.

The best watershed planning models include a strong focus on decentralized wastewater treatment as part of broader watershed planning.

Environmental Planning

Planners should bring to the table a holistic approach to watershed planning that includes an understanding of the role of decentralized wastewater treatment systems and their environmental impact on the watershed. Engineers, sanitarians, soil scientists, and regulators often view decentralized sewage disposal and management on a site-by-site basis, except as part of master planning for centralized sewerage systems. Planners and environmental professionals can offer a "bigger picture" approach.

As the EPA informed Congress in its "Response to Congress on the Use of Decentralized Wastewater Systems" (1997, Appendix B, Page B1):

> Wastewater system options are best selected in conjunction with broader, comprehensive community planning efforts to ensure that overall community goals are being met, such as environmental protection and land use goals. The planning process includes an analysis of the physical, social, economic, cultural, and environmental characteristics of the planning area. For example, if a watershed protection program already exists in a region to protect sensitive environmental areas, more advanced wastewater treatment (e.g., disinfection or nutrient removal) might be included as part of the watershed program, whether as part of a centralized or decentralized wastewater system (note that a decentralized system would allow the flexibility of installing advanced treatment only for those dwellings in close proximity to the sensitive areas). Similarly, if local land-use planning efforts include maintaining open space and conservation/woodland areas, wastewater management choices can complement such efforts (e.g., by encouraging cluster developments serviced by cluster wastewater systems).

The best watershed planning models include a strong focus on decentralized wastewater treatment as part of broader watershed planning. New York City, for example, gets much of its unfiltered water supply from a large watershed in the Catskill region of New York. Because the supply is unfiltered, New York City has adopted an exemplary watershed planning approach. This integrated approach focuses on the needs of communities hosting the water supply as well as all of the land-use and environmental issues that threaten the water supply. A recent risk assessment of the threats to New York City's water supply, however, found that decentralized wastewater systems were posing threats, especially in their treatment of microbial pathogens, to the water supply. The study identified necessary priorities as "first on microbial pathogens, second on organic precursors of disinfection byproducts, third on phosphorus, and fourth on turbidity and sediment" (Committee 2000, Executive Summary, 2).

The Double Impact of Decentralized Wastewater Systems on Land-Use Planning

Whether it is Texas colonias (Venhuizen n.d.) or suburban housing above sole-source aquifers, poor development patterns and inadequate attention

All over the country, the needs of decentralized wastewater treatment are influencing and skewing development patterns because either no centralized sewerage systems exist or none that can be used economically.

to decentralized wastewater treatment have resulted in environmental damage. Unfortunately, even when decentralized wastewater regulatory programs and market forces provide adequate attention to environmental impacts, and even when groundwater and surface water are protected, land-use planning in areas dominated by decentralized wastewater treatment systems need to take into account how the use of these systems can affect development patterns and how those patterns either do or do not conform to the community's overall vision for its growth and development. On the one hand, decentralized wastewater systems, in most cases, require more land for development, thereby resulting in lower density and the greater possibility of sprawl. (Clustered decentralized systems can help avoid this problem.) On the other hand, decentralized wastewater systems make it possible to build in areas that will result in the preservation of prime farmlands or other natural resources that might otherwise be under significant development pressure. This section of the report looks at how important planning is to the effective use of decentralized wastewater systems in achieving a community's vision for its form and future.

All over the country, the needs of decentralized wastewater treatment are influencing and skewing development patterns because either no centralized sewerage systems exist or none that can be used economically. Decentralized wastewater treatment can require large lots to provide dilution of nitrogen and adequate area for on-site systems, or can mandate development only on certain types of soils and sites.

Development with decentralized wastewater treatment, including both the placement and density of housing, can often be "premature" development because it limits the ability of a community to eventually rationalize its development patterns and expand urban infrastructure once municipal sewerage is available. Once land is platted out and developed around the needs of decentralized wastewater systems, it can be politically difficult and exceedingly expensive to change the density of development to serve other community needs. Homeowners, for example, resist infill development in a way that developers rarely do, and they do not want to help pay for a sewerage system if they have a functioning decentralized system.

Good planning and appropriate growth management strategies become critical if a community wants to avoid having their development patterns driven by the need for decentralized sewage treatment systems. Typical problems and challenges are highlighted in these cases from a number of states:

- Some communities in Vermont have seen new development occur in flat, fast-percolating, sandy, outwash plains overlaying community water supplies, on the best soils in those communities for farming, while development avoids glacial tills that can actually provide greater treatment and not compete with farmland (authors' first-hand experience). It is more difficult and expensive to develop decentralized systems on glacial tills, so in areas where well-drained land is available, the well-drained land is developed first, even if using that land competes with other community goals. Water supply protection ordinances, farm preservation zoning, or other appropriate strategies, could mitigate these problems.

- Some communities in Massachusetts have seen their efforts to encourage open space development and cluster development evaporate as developers instead build in areas before they are sewered, spreading development over large areas of land to take advantage of favorable "percolation" rates (authors' first-hand experience). Mandatory cluster, transfer of development ordinances, or adequate facilities ordinances, could mitigate these problems.

- The rich highly productive agricultural soils of California's Central Valley are perfect soils for decentralized wastewater treatment. Given that this is one of the fast-growing regions of the state, the competition for these soils creates obvious development pressures on farmland (Schiffman et al. 2003). Farm preservation zoning, purchase of agricultural preservation restrictions, maximum lot sizes, and minimum density requirements could mitigate these problems.

Incremental unplanned development, poor soils, future growth, and the economics of outside grants or developer funding obviously all have an influence on whether areas are or can be sewered.

This is certainly not to suggest that all areas of the country, even all areas with suburban or small town density, can or should, be sewered. The economics of centralized sewage treatment may not work well when there are fewer than 50 homes per mile of sewer line, and the lower densities may allow decentralized wastewater treatment to function effectively (GAO 1994). Incremental unplanned development, poor soils, future growth, and the economics of outside grants or developer funding obviously all have an influence on whether areas are or can be sewered.

Properly designed and sited decentralized wastewater treatment systems can offer sewage treatment on a par with or better than centralized sewage treatment facilities (depending on the siting and design of the decentralized system and the nature of the centralized system). Properly designed decentralized systems may also be much less expensive to build and maintain than centralized systems. (See, for example, Venhuizen's analysis of costs for centralized versus decentralized systems for South Texas colonias in GAO 1994 and Venhuizen n.d.)

Communities can use visioning and a master or comprehensive planning process to determine desirable ultimate densities and thereby determine if development should be at densities that only centralized sewage treatment facilities can support before individual premature subdivisions preclude such development patterns. The regulations should then implement that vision.

Many jurisdictions require that development have adequate facilities in place to accommodate that development. Florida's concurrency requirements, the popularity of adequate facility ordinances in Maryland, and other similar regulations around the country are examples of this approach. Sarasota County, Florida, is an excellent example of an adequate facilities process that takes sewerage into account (Sarasota County 1997). Montgomery County's Adequate Facilities Ordinance was adopted in 1973 to address the high costs of development and the inability of sewerage facilities to accommodate new growth and continues to evolve today (Montgomery County 2003; Maryland Office of Planning 1996). Without good comprehensive and regional planning, concurrency and adequate facilities requirements for centralized sewerage facilities can, however, create the same risks they do for roads and other infrastructure; they can inadvertently encourage development to leap frog into less desirable areas with less stringent regulations.

While an increase in the use of adequate facilities ordinances and other types of concurrency requirements has occurred, many of these ordinances address only roads and schools because these infrastructure items are among the most expensive capital improvements; for example, the Cary, North Carolina, system covers schools and roads only (Cary 1999). Some of the ordinances that cover wastewater treatment systems as well as other infrastructure cover only areas served by centralized sewerage systems, not areas currently served by decentralized wastewater treatment but that could someday be served by a centralized sewerage system.

TABLE 7. IMPACTS OF DECENTRALIZED WASTEWATER TREATMENT ON LAND-USE PATTERNS

Characteristics of Decentralized Wastewater Treatment Systems	Effect on Land-Use	Special Considerations
Leach field size	Providing a leachfield, especially on sites with high clay and silt content and high groundwater or ledge, requires larger lots.	
Disposal and treatment requirements	• Requires lots with certain soils • These well-draining soils may be productive farmland. • These soils may be current or potential drinking water aquifers (defined by the USGS as potentially productive aquifers)	• Discourages or prohibits siting in areas with high groundwater levels, ledge or bedrock, and inadequate soil for disposal and treatment. • Adequate treatment of nitrogen in coastal areas may not be possible without large lot sizes to dilute the nitrogen, effecting both development patterns and cost of housing. • Encourages development on sands and gravels

Generally, nitrogen is the limiting factor for algal growth in coastal waters, and phosphorus is the limiting factor for algal growth in fresh water systems. In other words, all of ingredients for algal blooms are present (water, light, substrate, nutrients) except for nitrogen in coastal waters and phosphorus in fresh water. Add these missing ingredients, and wild growth occurs, often blocking out recreation and commercial uses.

Properly functioning soil-based decentralized wastewater treatment systems work well at removing phosphorus. As a result, phosphorus is generally a problem only from lakefront homes with inadequate soil to treat sewage or with improperly designed systems or systems that pipe directly into the lake). Nitrogen, on the other hand, is much more difficult to treat, making it more likely that decentralized systems in coastal areas will aggravate nitrogen loading. The high price of land in coastal areas makes it difficult to increase minimum lot size to the extent necessary to provide high amounts of dilution. The size of the ocean and tidal action often makes nitrogen loading unnoticed, but in shallow estuaries and other low-volume, sensitive coastal environments, nitrogen loading can be significant.

It is possible to model nitrogen loads (as well as phosphorus and other nutrients) from typical land uses, including decentralized sewage systems, residential land uses, commercial land uses, agricultural land uses (e.g., from fertilizers and farm animals), and golf courses (Frimpter et al. 1988). Nitrogen loading from low-density residential uses, for example, is typically far lower than that from golf courses and agricultural uses. Many jurisdictions near nitrogen-limited waters establish minimum lot sizes to provide adequate dilution of nitrogen from decentralized wastewater treatment systems or require expensive nitrogen-reducing innovative sewage disposal systems. Both approaches escalate the cost of housing and put it out of reach of many residents.

Planners can often determine which areas of a community can easily accommodate conventional decentralized systems and which areas cannot (Engebretson and Tyler 2001). Soil surveys and maps of wetlands, waterways, and topography can all help with advance planning. Only site-specific investigations, however, are adequate to determine which sites can accommodate conventional systems, which require alternative systems, and which are unbuildable. This makes it difficult to know what land uses will occur absent a land-use regulatory structure.

In many rural communities, it is much easier politically to regulate health and environmental issues than land-use issues. As a result, some communities with only minimal land-use regulations do regulate decentralized sewage treatment discharges. The result, of course, is that in these communities, sewage regulations and not land-use planning can be the primary control on how a community develops. In such communities, growth will sometimes occur in the most undesirable places (e.g., on well-drained prime farmland or unstable alluvial outwash plains), but not on sites with shallow ledge or bedrock at the edge of a town center which, in many communities, might be the best place for development to occur. In addition, if sewage regulations are the primary growth management tool, new decentralized sewage technologies that allow more land to be developed may come when a community has not prepared for new growth.

In many rural communities, it is much easier politically to regulate health and environmental issues than land-use issues. As a result, some communities with only minimal land-use regulations do regulate decentralized sewage treatment discharges.

In Massachusetts, the state sanitary code (Title 5) limited the development of in-ground decentralized sewage regulations to permeable soils with percolation rates to 30 minutes per inch or faster. This made it, according to Beals and Thomas, a Massachusetts consulting firm, one of only two states that did not allow in-ground systems on soils with 60-minute–per-inch percolation rates. (See the discussion about percolation rates in the soils section of this report.)

In spite of years of public discussion, a liberalization of the rules to allow replacement of failed systems on soils with up to 60-minute-per-inch percolation rates, and the recommendation from a governor's blue ribbon committee on lowering the cost of housing, many communities were not prepared when the state finally liberalized the rate. Overnight, previously undevelopable land with percolation rates of 30 to 60 minutes per inch became developable. Neither the state nor most communities had even calculated the amount of acreage that would suddenly become developable nor had they conducted a comprehensive assessment of whether other existing growth management regulations were in place to deal with this potential flood of new development, so it was impossible to evaluate all of the effects of the change.

During the state rule-making process and the accompanying public debate, many environmental organizations, planners, and others expressed concern that expanded decentralized wastewater treatment options would create new undesirable development pressures. The public debate during the rule-making process was intense and mostly accurate at categorizing the issues:

> It's been used as a land use control, rather than a health code. The rules are ridiculously strict and should be realized in no small part because the state has an affordable housing crisis. (David Begelfer, National Association of Industrial and Office Parks, *Boston Globe*, December 1, 2002, p. 1)

> Precisely the kind of low-density development that we don't want—large, expensive homes that are not on sewer systems, and are far from town centers. It's exactly the kind of land-hungry practices we're trying to move away from. (Marc Draisen, head of the Metropolitan Area Planning Council, *Boston Globe*, December 1, 2002)

> The increase…will change the landscape of Western Massachusetts. Land that was previously unsuitable will become "buildable" in communities least prepared to manage growth. Many of the small towns that will be affected depend upon Title 5 to act as their land-use regulations. (Margaret McDonough, planner, on WesternMassPlanners list serve)

> No community wants unbridled growth, but we don't want to be seen as subscribing to a philosophy of "the ends justify the means." Title 5 is not and should never have been considered to be a growth management tool. (Rick Brown on Massplanners list serve)

TABLE 8. TREATMENT SYSTEM DECISION TREE

Issues	Most Likely Choice	Disadvantages
Density less than 50 homes per sewer mile	Decentralized systems more cost effective	Difficult to develop pedestrian-scale density and avoid sprawl
Nitrogen-limited waters (coastal)	Centralized sewer, low-density decentralized systems, or decentralized systems designed to reduce nitrogen	Sewer can create development pressures. Low density makes urban density difficult and can increase housing prices.
Walkable pedestrian-scale neighborhoods and infill desired	Centralized sewer, septic tank-effluent pump (STEP), or cluster systems.	More expensive. May be very difficult or expensive to retrofit if area is partially built-out. Good planning and management critical to determine and manage best model.
Soils unfavorable to decentralized treatment	Centralized sewer, septic tank-effluent pump (STEP), cluster systems, or alternative systems	Good planning and management critical to determine and manage best model.

In Massachusetts, it is clear that many in the planning and environmental communities are concerned that liberalizing decentralized wastewater treatment regulations to allow new technologies will create new growth pressures in previously undeveloped areas. Others, however, see new technologies as an opportunity to channel development into previously undeveloped areas and reduce pressures on farmland.

Schiffman et al. (2003) argue that allowing new technology in California's Central Valley, an area housing 5.5 million residents and undergoing some of the fastest growth in the country, would divert some new development from flat, well-drained farmland and onto non-prime farmland. Schiffman reports that the American Farmland Trust (AFT) found that 1 million acres of land in the Central Valley will be developed for single-family homes by 2040, 60 percent of which will be on prime farmland, and far more acres will be threatened by urban and suburban expansion. With most planners and environmental health directors reporting that they are basing their density requirements, in whole or in part, on the capabilities of conventional septic systems, more options for decentralized sewage on marginal soils and clustered development could significantly reduce farmland development pressures (Schiffman et al. 2003). As with every other aspect of growth management systems, planning for the appropriate type of decentralized systems can help support desired land-use patterns (Green Mountain Institute 2003).

Some decentralized wastewater treatment systems can allow some of the same development patterns and density as centralized systems. Clustered decentralized treatment and community systems can be designed to encourage the desired density necessary to avoid sprawl, without the cost and unfettered growth that might come from developing a centralized treatment system (Green Mountain Institute 2003; NAHB Research Center 2003; Joubert et al. 2004).

Planners should not only ensure that land-use regulations serve to channel growth to serve community goals, but obviously must also understand how regulations from other disciplines affect planning goals.

MANAGEMENT OF DECENTRALIZED WASTEWATER TREATMENT

Decentralized systems do not last forever, with the rate of failure often increasing over time (Dix and Hoxie 2001). Many systems that could last longer or perform better do not do so because they are not used or managed properly.

Around the country, public and private approaches to decentralized sewage management are allowing better functioning of decentralized systems and greater confidence in innovative and alternative systems, even those that require more maintenance and monitoring. Although often the province of engineers and sanitarians, planners are increasingly getting involved with the management of decentralized wastewater treatment systems as a condition of their approvals of subdivisions, special permits, special exceptions, and site plans.

Adequate operation and maintenance is critical for the proper functioning of most decentralized systems. Conventional in-ground systems typically require relatively little ongoing maintenance, and even more complex decentralized systems typically require less ongoing maintenance than a centralized sewage treatment plant. Every system, however, from complex package sewage treatment plants that might require monitoring several times a week to conventional in-ground systems, require some type of monitoring and maintenance.

Every system, however, from complex package sewage treatment plants that might require monitoring several times a week to conventional in-ground systems, require some type of monitoring and maintenance.

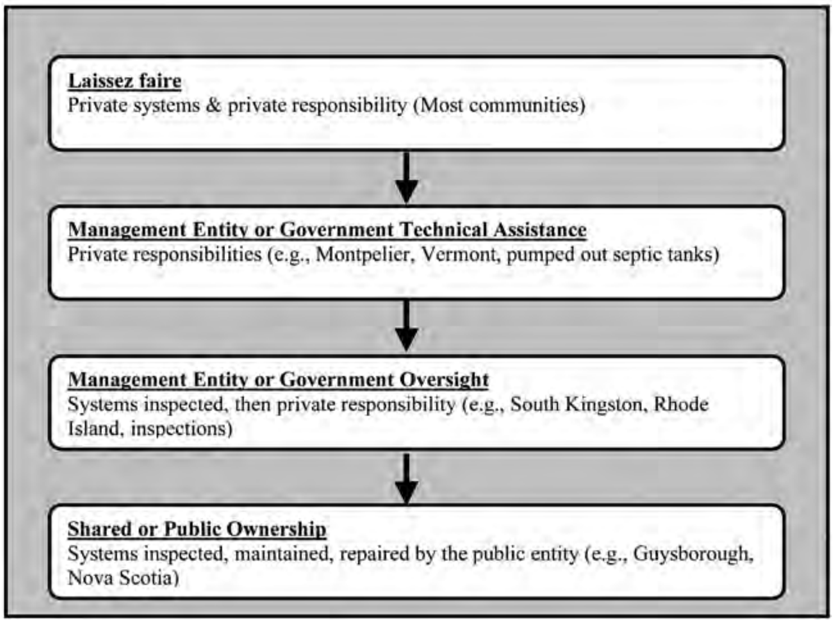
Twenty years ago, one of the authors of this PAS Report (Feiden) designed a siphon-fed low-pressure pipe wastewater system (LPP) for a decentralized sewage treatment public educator, presumably someone who understood the importance of maintenance. Both siphons and LPPs are low-maintenance systems, but they must be inspected or they will fail. To this date, in spite of many recommendations to do so, this homeowner has still not inspected this system. If is often the failure to adequately manage systems that gives even well-designed and well-sited systems a bad reputation.

The regulated community and their consultants often suggest greater use of new technologies, while regulators tend to be cautious of new technologies. One reason, of course, is that new technologies are unproven and may not always work adequately. Equally significantly, however, is that many new technologies can deliver as promised, but only when the systems are perfectly sited, installed, operated, and monitored. In the real world, however, systems are often imperfect, creating a greater need to focus on management. Planners should always be aware that many innovative and alternative systems require higher maintenance than traditional systems, and many "soft" solutions require greater management mechanisms.

There are both public and private sector solutions to address these issues. Public waste management districts and private homeowner associates or private service contracts can be crafted to provide the protection necessary.

Waste management districts and similar creative management approaches can improve the quality of decentralized wastewater treatment, reduce its cost, effectively serve as an insurance policy by spreading the costs of major repairs, and provide a greater comfort level for innovative and alternative systems. These management approaches range from simply providing free septic tank pumping services (Montpelier, Vermont), to waste management districts routinely inspecting all decentralized systems (as in South Kingston, Rhode Island), to complete takeover of the responsibilities for decentralized wastewater treatment systems (as in Guysborough, Nova Scotia). Figure 15 shows the continuum from a completely laissez faire system of system management to a completely public one of shared risks and no separation between the regulatory authority and the system owner.

FIGURE 15. DECENTRALIZED WASTEWATER MANAGEMENT CONTINUUM



Variations on these management approaches are used in many communities around the U.S. and elsewhere. Table 9 provides a sampling of the wide diversity of management approaches.

Proper installation of decentralized systems is critical to their function. In some jurisdictions, regulatory authorities inspect systems to ensure that they are properly installed (inspecting and documenting system construction, location, depth, and materials). In other jurisdictions, this is solely the responsibility of the designer or the contractor.

The EPA (2005a) provides guidance for jurisdictions identifying why and how to improve the management of on-site systems. Table 10 is the EPA's summary of management models.

RECOMMENDATIONS

Five recommendations stand out for planners working in communities with decentralized wastewater treatment systems. While these recommendations are especially important for those in suburban and rural areas, in all but the most urban communities, decentralized wastewater treatment is a factor influencing the development patterns of a community.

First, health and sanitary codes should never be a replacement for planning and growth management controls. Communities should plan as if decentralized wastewater treatment systems can be placed anywhere and for all types of development. This allows communities to be ready for development that might occur as new technologies become available or as the economics of projects allow investment in existing but previously unaffordable technologies.

Second, communities should plan for both those areas that should be served by centralized sewerage systems and those that should be served by decentralized systems. Issues of cost, community service, desirable densities, and water quality should all be considered in making these decisions.

Third, although design of decentralized wastewater treatment is typically the province of other professionals, planners should understand the

TABLE 9. DECENTRALIZED WASTEWATER MANAGEMENT MODELS

Location	Approach
Canandaigua Lake Watershed, New York	Multi-municipality program inspects failing and newly constructed decentralized sewage systems; funded by municipalities
Cass County, Minnesota	Management district constructs, managements, and maintains decentralized systems.
Georgetown, California	One of the first (1971) wastewater management districts for a subdivision (Lake Auburn Trails). The public utility district, funded with annual fees from property owners, coordinates all inspections, monitoring, and maintenance for 800 systems.
Gloucester, Massachusetts	Helped residents develop innovative and alternative decentralized systems as well as STEP (septic tank sewage effluent pump) sewerage system to avoid the need to install a huge traditional sewerage and sewage treatment system. Ongoing monitoring on decentralized systems is a part of the program.
Guysborough, Nova Scotia	District has taken over inspection, cleaning, maintenance, and repairs of decentralized systems. Capital costs from government funds and property capital connection levy. Maintenance funds from property tax surcharge on effected properties. "Flush and forget service" comparable to homes on centralized sewage treatment facilities.
Lake Panorama Onsite Waste Management District, Iowa	Regular inspections for early detection of problems and to allow the use of complicated systems.
Massachusetts, Minnesota, and many other U.S. states	Time-of-sale inspection programs to ensure systems are properly functioning. Privatized system where owners hire a consultant to conduct the review. Some kind of inspection is now required in approximately half of the states in the U.S.
Montpelier, Vermont	Free septic tank pump-out service encourages better maintenance. Funded from a sewage-benefit fee, which also partially funds a sewage treatment plant, under the theory that everyone benefits from clean water and urban densities.
Paradise, California	Ongoing monitoring and evaluation of decentralized systems, partially funded by annual operating fees
South Kingston, Rhode Island	The wastewater management district conducts mandatory inspections. The property owner is responsible for maintenance, repairs and improvements. (See regulations in Appendix A.)
Stinson Beach, California	Management district routinely inspects systems and requires property owners to make necessary repairs. Fees cover the service. The district has the ability to cut off water if its rules are not being followed.
Tennessee Wastewater Systems, Inc.	Owns, manages, and repairs cluster wastewater systems provided directly by housing developers. Funded by homeowners monthly fee.
Vermont	Association of Conservation Districts (now defunct) On Site Sewage Program worked as consultants to local governments, designing and inspecting private decentralized disposal systems as municipal agents to avoid the administrative overhead required to have one set of designers and a second set of regulators.
Washtenaw County, Michigan	Time-of-sale inspection programs to ensure systems are properly functioning.

Sources: Mancel 2001; National Small Flows Clearinghouse1996; RCAP Solutions 2004; Shephard 1996; South Kingston 2001; Stiles 2004; Task Force on Decentralized Wastewater Management 1995; EPA 2002; Washtenaw County 1999; and authors' observations

TABLE 10. DECENTRALIZED WASTEWATER MANAGEMENT MODELS

Typical applications	Program description	Benefits	Limitations
1. Homeowner Awareness Model			
• Areas of low environmental sensitivity where sites are suitable for conventional onsite systems	• Systems sited and constructed based on prescribed criteria • Maintenance reminders • Inventory of all systems	• Code-compliant system • Ease of implementation • Inventory of systems that is useful for tracking and areawide planning	• No compliance ID mechanism • Sites must meet siting requirements • Cost to maintain database
2. Maintenance Contract Model			
• Areas of low to moderate environmental sensitivity where sites are marginally suitable for conventional onsite systems due to small lots, shallow soils or low-permeability soils • Small cluster systems	• Systems properly sited and constructed • More complex treatment options (mechanical, clusters of homes) • Service contracts must be maintained • Inventory of all systems • Contract tracking system	• Lower risk of treatment system malfunctions • Homeowner's investment protected	• Difficulty tracking and enforcing compliance due to reliance on the owner or contractor to report a lapse in services • No mechanism provided to assess the effectiveness of the maintenance program
3. Operating Permit Model			
• Areas of moderate environmental sensitivity such as wellhead or source water protection zones, shellfish-growing waters, or bathing/water contact recreation areas • Systems treating high-strength wastes, or large-capacity systems	• Performance and monitoring requirements • Engineered designs allowed but may provide prescriptive designs for specific sites • Regulatory oversight by issuing renewable operating permits that may be revoked for noncompliance • Inventory of all systems • Tracking of operating permit and compliance monitoring • Minimum for large-capacity systems	• Systems can be located in more environmentally sensitive areas • Regular compliance monitoring reports • Noncompliant systems identified and corrective actions required • Less need for regulation of large systems	• Higher level of expertise and resources for regulatory authority to implement • Requires permit tracking system • Regulatory authority needs enforcement powers
4. Responsible Management Entity (RME) Operation			
• Areas of moderate to high environmental sensitivity where reliable and sustainable system operation and maintenance is required (sole-source aquifers, wellhead or source water protection zones, critical aquatic habitats, and outstanding value resource waters) • Cluster systems	• System performance and monitoring requirements • Professional O&M services through RME (public or private) • Regulatory oversight by issuing operating or NPDES permits directly to RME (system ownership remains with property owner) • Inventory of all systems • Tracking system for operating permit and compliance monitoring	• O&M responsibility transferred from the system owner to a professional RME that holds the operating permit • Problems identified before malfunctions occur • Onsite treatment in more environmentally sensitive areas or for treatment of high-strength wastes • One permit for a group of systems	• Enabling legislation might be necessary to allow RME to hold the operating permit for an individual system owner • RME must have owner's approval for repairs; might be conflict if performance problems are identified and not corrected • Need for easement/right of entry • Need for oversight of RME by the regulatory authority
5. Responsible Management Entity (RME) Ownership Model			
• Areas of greatest environmental sensitivity, where reliable management is required. Includes sole source aquifers, wellhead or source water protection zones, critical aquatic habitats, and outstanding value resource waters • Preferred management program for cluster systems serving multiple properties under different ownership	• Establishes system performance and monitoring requirements • Professional management of all aspects of decentralized systems • RMEs own or manage individual systems • Trained and licensed professional owners/operators • Regulatory oversight through NPDES or other permit • Inventory of all systems • Tracking of operating permit and compliance monitoring	• High level of oversight if system problems occur • Model of central sewerage that reduces the risk of noncompliance • Onsite treatment in environmentally sensitive areas • Effective planning and watershed management • Potential conflicts between the user and RME removed • Greatest protection of environmental resources and homeowner investment	• Enabling legislation or formation of special district might be required • Might require significant financial investment by RME for installation or purchase of existing systems or components • Need for oversight of RME by the regulatory authority; might limit competition • Homeowner associations may not have adequate authority

Source: EPA 2005a

technology and the issues enough to understand how wastewater treatment influences the way a community develops.

Fourth, planners can bring to the table the skills necessary to ensure that decentralized wastewater systems are managed correctly, especially in communities that choose to adopt waste management districts.

Fifth, and finally, all of these issues should be considered when reviewing project specific applications to ensure that a community's overall planning objectives are not lost in the review of a specific project.

There is no single answer that will work in all communities. Generally, centralized sewerage treatment systems are important to achieve urban densities over large areas, a critical goal for communities that want sustainable development. On the other hand, decentralized systems are often less expensive and often do not require lower densities than those created by the community's growth management regulations or economic or political pressures. Decentralized systems, especially clustered wastewater treatment systems, are often compatible with the preservation of open space and can be placed near and even under community recreation areas.

Sample Regulations for Decentralized Wastewater Management Districts

The South Kingstown, Rhode Island, Wastewater Management District inspects decentralized systems while the property owner is responsible for maintenance, repairs and improvements.

The Little Dover, Guysborough, Nova Scotia, Wastewater Management District goes further and inspects, maintains, and repairs systems as necessary. The same management district maintains both decentralized systems and buildings connected to the central sewer.

THE SOUTH KINGSTOWN, RHODE ISLAND, ON-SITE WASTEWATER MANAGEMENT DISTRICT (SEPTEMBER 7, 2001)

SECTION 1.0 FINDINGS AND PURPOSE

The South Kingstown Comprehensive Plan recognizes septic systems as a source of ground and surface water contamination in the Town, and states that the "Town shall adopt a town-wide Wastewater Management District." The South Kingstown On-site Wastewater Management Plan approved by the Town in June of 1999 and Rhode Island Department of Environmental Management (RIDEM) in October 1999 outlines a town-wide program to ensure the proper design, inspection and management of on-site sewage treatment systems. The On-site Wastewater Management Ordinance adopted by the Town Council [in 2001] provides a framework for the efficient inspection, repair and maintenance of Individual Sewage Disposal Systems (ISDS) in South Kingstown. These regulations provide the technical and administrative procedures governing implementation of the On-site Wastewater Management Ordinance.

SECTION 2.0 DEFINITIONS

2.1 Any term not defined herein shall be governed by the definition as it appears in the current RIDEM Rules and Regulations Establishing Minimum Standards Relating to the Location, Design, Construction and Maintenance of Individual Sewage Disposal Systems (hereinafter ISDS Regulations) and the South Kingstown On-site Wastewater Management Ordinance. Any other term not defined therein shall be governed by the definition as in appears in the South Kingstown Zoning Ordinance

2.2 Access Riser: A structurally sound and water tight inspection port or manhole, which at its lowest point attaches to a septic tank or other component of an ISDS and extends upward to the ground's surface, allowing visual inspection and where necessary physical access to the ISDS for the purposes of maintenance and repair.

2.3 Contaminant: Any physical, chemical, biological or radiological substance which enters the hydrological cycle through human action and may cause a deleterious effect on ground and/or surface water resources; it shall include but not be limited to hazardous waste, nutrients, pathogens and sanitary sewage.

2.4 RIDEM: The State of Rhode Island, Department of Environmental Management or its successor organization.

2.5 Director: The Director of the RI Department of Environmental Management or any subordinate(s) to whom the Director has delegated the powers and duties vested in her/him pursuant to RI General Laws, Chapters 46-12 and 42-17.1, as amended, or any other duly authorized agent.

2.6 Effluent: Sewage, water or other liquid, partially or completely treated or in its natural state, flowing out of any component of an ISDS or flowing over the ground's surface or beneath the ground in groundwater.

2.7 Enhanced Treatment Systems: On-site wastewater treatment that uses advanced treatment technologies, which provide for enhanced removal of one or more contaminants (e.g. nutrients, microorganisms, BOD, TSS) as compared to conventional septic systems.

2.8 Groundwater Protection Overlay District (GPOD): The area defined by lots of record which are indicated as the GPOD on the official zoning map of the town of South Kingstown. The GPOD is superimposed over any other zoning district established under the Zoning Ordinance of the Town of South Kingstown. The GPOD is governed by Article 20, section 2010 Establishment of District, South Kingstown Zoning Ordinance Nov 7, 1994, as amended.

2.9 Handbook: The Rhode Island Department of Environmental Management's Septic System Check-Up: The Rhode Island Handbook for Inspection as may be amended from time to time.

2.10 Hazardous Waste: (1) Wastes which include, but are not limited to, those which are toxic, corrosive, flammable, or reactive; and/or (2) Wastes as defined in the RI Hazardous Waste Management Act, Section 23-19.1-4 or in any regulation or amendment adopted pursuant thereto; and/or (3) as defined under section 3.25 of the RI. Department of Environmental Management "Rules and Regulations for Hazardous Waste Generation, Transportation, Treatment, Storage and Disposal."

2.11 ISDS Commission: The Commission established to assist the Program Administrator or his/her designee in matters concerning the implementation and administration of this ordinance and the On-site Wastewater Management Program.

2.12 ISDS Inspections: One of two types of ISDS inspections that may be undertaken to gather baseline information, assess maintenance needs, determine the condition of an ISDS at the point of home sale, or determine the cause of ISDS failure.

a) First Maintenance (Baseline) Inspection: The initial inspection performed on an ISDS and site to gather baseline information. All cesspools and tanks for those ISDS installed prior to 1970 are pumped as part of this inspection to better evaluate the existing condition of the system. First Maintenance Inspections involve the location of system components and more detailed data gathering that is not usually necessary for subsequent routine inspections.

b) Routine Maintenance Inspection: An inspection of an ISDS and system site to determine the need for pumping, establish future inspection schedules and to assess whether any repairs are necessary.

2.13 Maintenance: The periodic cleaning of any leaching chamber, cesspool, septic tank, building sewer, distribution lines, or any other component of an ISDS for the purpose of removing any accumulated liquid scum and/or sludge. The term "maintenance" shall also mean any regularly required servicing or replacement of related mechanical, electrical or other equipment.

2.14 On-site Wastewater Management Program (OWMP): A town-wide program of various zoning and subdivision regulations, ordinances, educational programs, management practices and financial incentives that are designed to help protect the integrity of South Kingstown's ground and surface water through the proper management, design, siting, maintenance and installation of ISDS.

2.15 Package Treatment Plant: A modular treatment facility of State approved design and construction. For purposes of the On-site Wastewater Management Ordinance, package treatment plants are considered ISDS.

2.16 Person: Any individual, group of individuals, firm, corporation, association, partnership, or private entity, including a district, county, city, town, or other government unit or agent thereof, and in the case of a corporation, any individual having active and general supervision of the properties of such corporation.

2.17 Wastewater: Any human or animal excremental liquid or substance, putrescible animal or vegetable matter, garbage, or filth, including the discharge of toilets, laundry tubs, washing machines, sinks, dishwashers, and the contents of septic tanks, cesspools, or privies.

2.18 Wellhead Protection Area: The critical portion of a three dimensional zone surrounding a public well or well field, through which water will move towards and reach such well or well field as designated by the Director of RIDEM or as adopted by the Town.

SECTION 3.0 ADMINISTRATION AND PROCEDURES

3.1 Program Administrator and On-site Wastewater Specialist:

a) The On-site Wastewater Management District shall be overseen by the Public Services Director who shall serve as Program Administrator. The On-site Wastewater Specialist may serve as the Program Administrator's designee and is responsible for the day to day operation of the program. The duties of the On-site Wastewater Specialist shall be in conformance with the On-site Wastewater Management Ordinance, these regulations and the attached job description.

b) At a minimum, the person should have a demonstrated competency in the area of soils, ISDS functioning, inspection and repair procedures, including innovative and alternative technology. The Town Manager shall be responsible for hiring said individual.

c) The On-site Wastewater Specialist shall prepare a monthly report for the Program Administrator and ISDS Commission regarding program implementation including progress and any problematic situations. It shall include such items as the status of any associated grants, consent agreements, notice of violations, number of inspections, number of retrofits, septic system repairs, and other pertinent information.

3.2 ISDS Commission:

a) The ISDS Commission shall hold a meeting at the call of the chair, vice-chair, secretary, or by the vote of a majority of its members. The ISDS Commission shall comply with the procedures of the Conservation Commission by-laws.

b) The ISDS Commission will provide guidance in the implementation of the On-site Wastewater Management Program and associated grant and loan programs

c) The ISDS Commission will carry out its responsibilities as detailed in the On-site Wastewater Management Ordinance.

d) The ISDS Commission will meet with ISDS owners to provide assistance on issues of on-site wastewater management including repairs to failed systems.

SECTION 4.0 INSPECTIONS

4.1 Inspection Types: The WWM Ordinance requires two types of inspections as described in the Handbook: First Maintenance (Baseline) Inspection and Routine Maintenance Inspection.

a) A First Maintenance (Baseline) Inspection of each ISDS in Town shall be conducted in order to obtain baseline information and to determine a routine maintenance schedule and potential upgrade requirements. All cesspools and those septic tanks for all ISDS installed prior to 1970 shall be pumped as part of this inspection to better evaluate the condition of the system. First Maintenance Inspections involve some data gathering and location of system components that is not usually necessary for subsequent Routine Maintenance Inspections.

b) Routine Maintenance Inspections are generally conducted after the First Maintenance (Baseline) Inspection and may occur between septic tank pump-outs. The frequency of Routine Maintenance Inspections are determined by the conditions found at the First Maintenance (Baseline) inspection. Where appropriate, Routine Maintenance Inspections for any given ISDS may be limited to sludge and scum measurements within a septic tank. A property owner, with proper training through the University of Rhode Island's On-site Wastewater Training Center or other program approved by the ISDS Commission, may conduct Routine Maintenance Inspections on their own ISDS.

4.2 Inspection Frequency and Notification: The Wastewater Specialist shall send written notice to ISDS owners of the need to schedule the First Maintenance Inspection as well as subsequent Routine Maintenance Inspections. The owner must schedule an inspection with an approved inspector within forty-five (45) days of the date of notice. In general, inspection frequency for Routine Maintenance Inspections shall be based on the results of the First Maintenance Inspection, subsequent Routine Maintenance Inspections and procedures outlined in The Handbook. These include, but are not limited to, system age, household occupancy, tank size, sludge and scum measurements and when the system was last pumped. The Program Administrator shall send written notice to ISDS owners of the need to schedule an inspection of their septic system. This inspection must be scheduled within forty-five days of the date of notice. After a system has been inspected the owner will receive notification of the maintenance requirements and the time frame for the next inspection. The Program Administrator may send a reminder notice to the owner as the date for the next Routine Maintenance Inspection approaches.

4.3 Inspection Reports: Standard inspection forms shall be those used in The Handbook. These forms may be modified by the Program Administrator as needed to meet the technical and administrative needs of the program. The property owner shall provide the ISDS inspector with any available pertinent information, including but not limited to, the use, age, location, maintenance history and design of the ISDS. The completed inspection report shall detail the results of the inspection, pumping or other maintenance requirements, the time frame for the next inspection and/or upgrade requirements for the ISDS. The inspector shall give the property owner and the Program Administrator an inspection report that details the condition of the ISDS, including but not limited to, system components, required maintenance and the date for the next Routine Maintenance Inspection. inspection schedule and maintenance requirements. The ISDS inspector shall provide the Program Administrator and the property owner with a written copy of the inspection report. The Program Administrator shall be responsible for maintaining ISDS inspection, maintenance and upgrade records.

4.4 ISDS Maintenance and Owner's Responsibility: The ISDS owner(s) shall assume all responsibility for hiring a septage hauler or maintenance contractor to complete the maintenance and inspection requirements contained in the ISDS inspection report within the time frame required. As proof of compliance, the property owner shall submit a receipt for pumping and other system maintenance to the Program Administrator within thirty (30) days of the date stipulated in the ISDS inspection report.

4.5 Failed ISDS: If an inspection reveals a malfunctioning or failed ISDS, the Town-approved inspector shall immediately notify the Program Administrator and the ISDS owner and send a copy of the inspection report to both parties. In the event that frequent pumping records indicate a failed system, the Program Administrator shall notify the owner in writing of a potential problem and the need for a system inspection. Technologies selected to replace failed systems shall be consistent with Town policy regarding treatment standards. At the owner's request, and in order to facilitate the ISDS repair application with RIDEM, the Program Administrator or his/her designee will meet with the owner to provide technical and administrative assistance regarding ISDS repairs. The Program Administrator may request advisory recommendations from the ISDS Commission. Such assistance shall be designed to help the owner through the application process, to understand technical issues and appropriate system choices and to solve the problem in a fair and expeditious manner. It does not preclude the owner's responsibility to hire needed professional assistance.

The Program Administrator shall give the owner of a failed system a written Notice of Violation (NOV) to repair the system. A copy of said notice shall also be sent to the Department of Environmental Management. The owner shall be given thirty (30) days to contact RIDEM and apply for a permit to repair or replace the system as necessary. A copy of the application to RIDEM shall be provided to the Program Administrator. Notification of RIDEM by the Program Administrator or his designee does not replace or preclude the obligation of the owner to notify RIDEM. The property owner shall notify the Town as to the expected timetable for repairs to be completed.

SECTION 5.0 PHASING:

The implementation of Section 7.0 of the WWM Ordinance of shall occur over a period of seven years in accordance with the map titled 'Wastewater Management Inspection Schedule', dated 6-15-01. Phasing shall begin in the Green Hill Pond watershed, and then proceed in order to the watersheds of the other coastal ponds and Narrow River, the Groundwater Protection Overlay District (GPOD) and lastly to the remainder of the Town.

The Program Administrator shall have the authority to alter the phased inspection schedule by ordering the inspection of any ISDS when it has been determined that the ISDS is in need of immediate improvements.

SECTION 6.0 EDUCATION AND TECHNICAL ASSISTANCE

6.1 Education: The Conservation Commission serving in its capacity as the ISDS Commission shall develop and oversee an annual education strategy that is designed to facilitate the effective implementation of the On-site Wastewater Management Plan, the On-site Wastewater Management Ordinance and related zoning and subdivision regulations. The education plan shall inform people about the findings, benefits and goals of on-site wastewater management in South Kingstown and will be on file in the Planning Department and Public Services Department. It shall include, but not be limited to the following:

- Proper inspection, operation and maintenance of ISDS.
- Operation and management framework of the program.
- Proper disposal of hazardous waste, including household hazardous waste.
- Water conservation.
- Protection of sensitive resources.
- Use of environmentally sensitive cleaning products.
- Use of alternative and innovative septic systems and associated technologies.
- Availability of financial assistance.
- Costs to homeowners to ensure compliance with WWMO provisions.

The plan must be developed by May 31st each year for implementation the following fiscal year.

6.2 Technical Assistance: All persons applying to RIDEM for new ISDS installations, repairs or alterations are encouraged to meet with the Program Administrator On-site Wastewater Specialist or the ISDS Commission prior to beginning system design in order to ensure that the design is consistent with Town policy regarding treatment standards.

SECTION 7.0 MISCELLANEOUS REGULATIONS FOR ISDS OPERATION AND SITING

7.1 Septage Disposal: Septage or contents pumped from an ISDS shall be discharged at the South Kingstown Wastewater Treatment Facility or other State-approved septage receiving facility.

7.2 Septic Tank Additives and Improper Discharges to ISDS: The use of septic tank additives shall follow RIDEM's policy, which prohibits the use of chemical additives. There is no evidence that biological additives provide any benefit to the functioning and maintenance of an ISDS. The use of biological additives does not relieve a property owner from the obligations of this ordinance. The disposal of hazardous wastes, to an ISDS shall be prohibited. Backwash from a water filtration system into a septic tank is harmful to the operation of the ISDS and is best discharged to a separate infiltration line. There shall be no discharge of rainspouts, basement sumps, floor drains, or any other drains, other than those carrying household wastewater, to an ISDS.

7.3 Garbage Disposal: Garbage disposal discharges to a new ISDS shall be permitted only on systems that are equipped with an oversized tank, capable of handling the excess solids, and with an effluent filter located on the tank's outlet. ISDS with existing garbage disposals may require more frequent pumping.

7.4 Water Saving Devices: Water saving devices shall be required on all appropriate fixtures as per the RI State Building Code, including 1.5 gallon flush toilets on new or remodeled construction.

7.5 Occupancy and Use: In order to ensure proper treatment of effluent functioning of an ISDS must be sized to handle the number of persons living in the house the occupancy or use of the house should not exceed the capacity of the system as calculated using the RIDEM standards. This includes properties that are rented in excess of 1 week per year.

7.6 Accessibility, Effluent Filters and Inspection Ports: It is recommended that all ISDS that presently have no access risers be equipped with three access risers to grade located at the inlet, center and outlet of the septic tank and an effluent filter be installed at the outlet end of the septic tank. It is recommended that all ISDS that have only an existing center access riser be equipped with access risers at the inlet and outlet ends of the septic tank and an effluent filter be installed at the outlet end of the septic tank. Access risers shall be watertight and a minimum of twenty-two inches in diameter. These measures will help locate ISDS, facilitate the inspection and pumping of a septic tank and ultimately the longevity of the ISDS. The ISDS Commission and Program Administrator will provide technical information and support regarding the installation of these structures on both new and existing ISDS.

7.7 Watertight Septic Tanks: Per RIDEM regulations, any existing tank that leaks may be declared a failed system. All septic tanks installed after the effective date of the ordinance shall be certified watertight in accordance with ASTM minimum standards or those developed by the ISDS Commission. Tank installation must be done in accordance with manufacturer's requirements. In addition, tanks installed after the effective date of the ordinance must be site tested to ensure that they are watertight. The accepted procedure(s) for site testing tanks as watertight shall be available from the South Kingstown Public Services Department.

7.8 Cesspools: Cesspools are a sub-standard and inadequate means of on-site wastewater treatment. All cesspools are considered to be malfunctioning systems and shall be replaced with an on-site wastewater system which conforms with current state and local standards within 12 months after the sale of a property or within five years of the date of the First Maintenance (Baseline) Inspection, whichever comes first.

A property owner may request, in writing, a review by the Public Services Director for an alternative to replacing a cesspool. Upon receipt of the request, the Public

Services Director shall endeavor to work out with the property owner an economically feasible plan to bring the on-site wastewater system into compliance with state and local standards, which alternative may include an extension of time in which to comply with this section, the imposition of interim measures that ensures the protection of the environment and the public health, safety and welfare, and/or a remediation plan. The Public Services Director may request an advisory opinion from the ISDS Commission regarding these matters. The Public Services Director may allow an alternative to replacing a cesspool upon a finding that all of the following standards are satisfied:

(a) requiring the replacement of the cesspool in strict conformance with this section would be economically infeasible, considering all the relevant facts and circumstances of the individual case; and,

(b) the system does not present an immediate public health and/or environmental threat; and,

(c) the alternative system provides a level of environmental protection that is at least equivalent to that required by RIDEM.

The decision of the Public Services Director shall be in writing and shall state specific reasons for the denial or approval.

LITTLE DOVER, GUYSBOROUGH, NOVA SCOTIA, WASTEWATER MANAGEMENT DISTRICT BY-LAW (LOCAL GOVERNMENT RESOURCE HANDBOOK, MARCH 2003)

BEING A BY–LAW regulating the use and maintenance of a Wastewater Management System, and the discharge of waters and wastes into a community sewer system, as well as the installation of septic tanks and sewer laterals on private lands in the Wastewater Management District, and providing penalties for violation thereof.

PART 1: DEFINITIONS

1. Unless the context specifically states otherwise, the meaning of terms used in this By-Law shall be as follows:

a) **BUILDING SEWER –** shall mean any sewer, tanks, pumps pipes or piping system which is located on private property and which connects the building sewer or drainage system or the building sanitary conveniences to the sanitary sewer, storm sewer or combined sewer or other places of disposal;

b) **COMMITTEE:** shall mean the Public Services Committee of the Municipality of the District of Guysborough, or such other Committee of Council as shall be given responsibility for sewer services by the Municipality of the District of Guysborough from time to time;

c) **INDIVIDUAL ON-SITE SEWAGE DISPOSAL SYSTEM:** shall include the septic tank with disposal field and all other private sewage disposal systems which are within a Wastewater Management District;

d) **INDUSTRIAL WASTE:** shall mean any slimes, tailings, effluent, sewage or other waste products of any kind whatsoever which is the result of an industrial undertaking, and which is intended to be discharged from the industrial undertaking to a building sewer;

e) **INSPECTOR:** shall mean Director of Public Works or any other Municipal employee or employees of any Consultant Firm authorized by the Municipality of the District of Guysborough to carry out inspections or investigations on behalf of the Municipality of the District of Guysborough as may be required under this By-Law;

f) **MUNICIPAL COUNCIL:** shall mean the Council of the Municipality of the District of Guysborough;

g) **MUNICIPALITY:** shall mean the Municipality of the District of Guysborough;

h) **OWNER:** shall mean an owner, a part owner, joint owner tenant in common or joint tenant of the whole or any part of any land or building, and includes a trustee, an executor, a guardian, an agent, a mortgagee in possession or other person having the care or control of any land or building in case of the absence or disability of the person having title thereto;

i) **PUBLIC SEWER:** shall mean a sewer which is located on public or private property within the Wastewater Management District which is owned and maintained by the Municipality of the District of Guysborough;

j) **SANITARY SEWAGE:** shall mean water-carried wastes from the sanitary conveniences of residences, commercial buildings or premises, institutions, and industrial establishments, but excluding storm sewage as hereinafter defined;

k) **SANITARY SEWER:** shall mean the sewer pipe system which carries sanitary sewage, as defined hereinbefore, and to which storm, surface and ground water are not intentionally admitted;

l) **SEWER LATERAL:** shall mean any piping systems which runs from the private property line to the public sewer, and is not within the portion of the system owned or operated by the Municipality;

m) **SLUDGE:** shall mean any discharge of sewage which in concentration of any given constituent or in quantity of flow exceeds more than five times the average twenty-four hour concentration or flow for a period in excess of fifteen minutes;

n) **STORM SEWAGE:** shall mean ground, surface, and storm waters which are unpolluted other than by their contact with the natural environment, and industrial cooling water, and unpolluted process water;

o) **STORM SEWER:** shall mean a pipe system which carries storm and surface waters, industrial cooling water, or unpolluted process water but excludes sanitary sewage;

p) **STREET:** shall mean any public road in the Municipality of the District of Guysborough.

PART 2: ESTABLISHMENT OF WASTEWATER MANAGEMENT DISTRICT AREA AND COMMITTEE

1. The establishment of a Wastewater Management District shall be pursuant to the provisions of Part 14, Section 342 of the Municipal Government Act, R.S.N.S. Chapter 295 or any amendments thereto.

2. The Municipality hereby establishes the Wastewater Management District for the Community of Little Dover, the boundaries of which are as described in Schedule "A" hereto attached, and shown on Schedule "B" hereto attached.

3. The Wastewater Management System may consist of a public sewer and individuals on-site sewage disposal systems as contained in the Wastewater Management District Area.

4. When the Municipal Council deems it necessary that a public sewer or individual on-site sewage disposal system be constructed in the Wastewater Management District Area, the Council may order, by resolution, and without the authorization of any petition of the owners, that such public sewer or individual on-site sewage disposal system be constructed and all the provisions of the By-Laws related to and regulating the use of such systems in force in the Municipality by and are hereby made applicable to any such systems constructed by virtue of such resolution.

5. The Municipal Council may, by resolution, order the repair and improvement of any public sewer or individual on-site sewage disposal system, whenever the same shall be considered necessary or desirable, and to lay out, excavate and complete such system within the Wastewater Management District Area and for any other work necessary to be done in connection therewith.

6. The management, operation and control of the Wastewater Management District as defined in Clause 2 is vested in the Municipal Council of the Municipality of the District of Guysborough. The Council shall annually appoint a Committee to be responsible for Wastewater Management Systems within the Municipality. It shall be the duty of this committee to make annual reports to Council concerning the operation, construction and installation of all public sewers and individual on-site sewage disposal systems within the Wastewater Management District Area. Council may refer to such Committee any questions relating to any proposed installation of a public sewer or individual on-site sewage disposal system in any part of the Wastewater Management District Area for study and report. This Committee shall be responsible for the supervision of the enforcement of the By-Laws relating to public sewers and all individual on-site sewage disposal systems within the Wastewater Management District Area.

This Committee shall oversee the construction and installation of public sewers and individual on-site sewage disposal systems in any Wastewater Management District Area established by the Municipality of the District of Guysborough.

PART 3: THE REQUIRED USE OF THE WASTEWATER MANAGEMENT SYSTEM

1. The owner of any dwelling house, shop, store, office or other building, the nearest part of which is not more than two-hundred feet (200’) from any portion of the public sewer or individual on-site sewage disposal system within the Wastewater Management District Area, is hereby required, at his expense, to connect any facilities discharging sanitary sewage directly with the disposal system provided by the Municipality in accordance with the provisions of the By-Law, within thirty (30) Days after the date of the official notice to connect. In circumstances where the Municipality provides a tank within private property, the property owner shall be responsible for the installation of the sewer lateral from the dwelling or building to the tank. Where the septic tank forms part of the treatment system the Municipality shall install the appropriate tank and all piping connections from the tank to the main line in the street. The tank installation shall include any necessary pumps, etc. with the power supply for any pumps within private property to be provided by the property owner.

2. Where a public sewer is not available within the Wastewater Management District Area, the building sewer system shall be connected to a private on-site sewage disposal system and will be up-graded to the Department of Environment requirements at the cost of the Municipality, excluding the cost of laying pipe from the foundation of the building to the individual on-site sewage disposal system as provided by the Municipality.

PART 4 – BUILDING SEWERS AND CONNECTIONS

1. a) No person, firm or corporation shall make any opening or openings to uncover any public sewer or individual on-site sewage disposal system or connect a building sewer, private drain or sewer within the public sewer or individual on-site disposal system within the Wastewater Management District Area, without first obtaining a permit therefore from the Municipality, which permit shall be in the form of Schedules “C” and “D” to this By-Law. Provided however, that notwithstanding the issuance of any such permit, the person to whom any such permit is issued shall be liable for any damage or injury to the public sewer or individual on-site sewage disposal system caused by him, his servants, agents or workmen in making any such connection.

b) It shall be the duty of any person, firm or corporation who connects any on-site sewage disposal system, or drain while excavating, to securely protect the excavation in such manner as may be directed by the Inspector, and to use a licensed installer for the purpose of such work.

c) There shall be two classes of building sewer permits:

(i) for residential and commercial service; and

(ii) for service to establishments producing industrial wastes.
In either case, the owner or his agent shall make application on a form furnished by the Inspector, which form shall have the context given in Schedules "C" and "D" of this By-Law, as is applicable. The permit application shall be supplemented by any plans, specifications, and other information as is deemed necessary by the Municipality, to determine whether the application meets the requirements of this By-Law.

2. All costs and expenses incidental to the installation and connection of the building sewer shall be borne by the Owner. The Owner shall indemnify the Municipality from any loss or damage that may directly or indirectly be occasioned by the installation of the building sewer.

3. A separate and independent building sewer shall be provided for every building; except where one building stands at the rear of another on an internal lot and no private sewer is available or can be constructed to the rear building through an adjoining alley, courtyard or driveway. The building sewer from the front building may be extended to the rear building and the whole considered as one building sewer.

4. Old building sewers may be used in connection with new buildings only when they are found, on examination and testing by the Inspector, to meet all the requirements of this By-Law.

5. Size, slope, alignment, materials of construction of the building sewer, and the methods to be used in excavating, placing of the pipe, jointing, testing, backfilling the trench, and connection to the public sewer or individual on-site sewage disposal system shall all conform to the requirements of the Municipality as set out in Part 5 of this By-Law.

6. Whenever feasible, the building sewer shall be brought to the building at an elevation below the basement floor. In all buildings in which the sewer drain is too low to permit gravity flow to the public sewer system or individual on-site sewage disposal system, sanitary sewage carried by such sewer drain shall be lifted by an approved means and discharged to the public sewer or individual on-site sewage disposal system at the expense of the owner

7. The person who originally made application for the building sewer permit shall notify the inspector when the building sewer is ready for inspection and connection to the public sewer. The entire works shall be performed under the supervision of an inspector. Backfilling of the building sewer shall not be undertaken until the inspections are completed and certificates of approval by the owner.

PART 5: APPLICATION TO CONNECT

1. Before any person constructs a building sewer, he shall apply to the Municipality for directions as to the proper lines and grades applicable to his building sewer and the Inspector shall assign suitable lines and grades for any building sewer.

2. (1) The construction and installation of any building sewer shall be under the direct supervision of the Inspector and the specification for labour and materials under which the public sewer was constructed are to be considered as part of the specification for any such building sewer modified, however, so as to be applicable to the building or buildings situated on the property to be served by such building sewer.

(2) The installation requirements necessary before connections of the public sewer or individual on-site sewage disposal system is permitted are as follows:

a)(i) Any building sewer shall, from a point three feet (3′) outside of the foundation of the house or building to the street line or individual on-site sewage disposal system shall be of first quality materials, the pipe having a diameter of four to six inches (4″ to 6″);

(ii) Sewer laterals must not be less than four inches (4″) in diameter and be constructed of PVC DR28 with ring tight joints or approved equivalent;

(iii) The building sewer may be laid in a common ditch with the water line but it must be buried at a lower elevation and at a minimum distance of twelve inches (12″) away from the water line;

(iv) The building sewer must be laid on a bed of tamped sand or approved fine gravel of not less than six inches (6″) in depth and must not be backfilled until inspected and approved by the Inspector;

(v) When backfilling is permitted a topping of not less than six inches (6″) of sand or approved fine gravel must be laid over the sewer line before previously excavated backfill material is replaced into the ditch to bring it up to grade.

b) (i) An application for a permit to make connection to sewer main trunk lines or individual on-site sewage disposal systems must be made by the property owner to the Municipality or its appointed agents;

(ii) When a permit is issued a property owner can proceed with installation of laterals under conditions of the above noted specifications and regulations;

(iii) Backfilling of ditches must not be undertaken until the installations are inspected and the approval certificate received by the owner.

3. All sewers shall be constructed in accordance with the provisions of the Public Highways Act, R.S.N.S. 1989, Chapter 371, and amendments and regulations thereto and shall cause as little obstruction as possible for pedestrians and vehicular traffic during installations.

4. (1) Whenever any building sewer is abandoned, the owner shall effectively block up the connection at the property line so as to prevent sewage from backing up into the soil, or dirt being washed into the sewer.

(2) Where the owner does not effectively block up the building sewer as required under the provisions of sub-section (1) within seven (7) days from receipt of notice from the Inspector, requiring him to do so, the Inspector may cause the same to be done and the cost of such work caused to be done may be recovered as a debt by the Municipality from the owner in an action in any court of competent jurisdiction.

5. (1) Where under any provision of this By-Law approval or permission of the Inspector appointed by the Committee is required before any work or thing may be done, an appeal shall lie to the Committee from the decision of the Inspector, refusing to grant approval or permission, and the Committee shall either direct the Inspector to grant the approval or permission or uphold the decision of the Inspector.

(2) The right of appeal provided in sub-section (1) shall expire thirty (30) days after the Inspector gives his decision in writing to the owner with respect to the approval or permission.

PART 6: USE OF SEWAGE DISPOSAL SYSTEMS WITHIN THE WASTEWATER MANAGEMENT DISTRICT AREA

1. No person, firm or corporation shall discharge or cause to be discharged any storm water, surface water, ground water, roof run-off, sub-surface drainage, unpolluted cooling water, or unpolluted industrial process waters to any sanitary sewer.

2. No open gutter, cesspool, privy, vault, cellar, underground drain or exhaust pipe from any machine shall be connected with any public sewer or individual on-site disposal system.

3. No person, firm or corporation shall injure, break or remove any portion of the public sewer individual on-site sewage disposal system or building sewer.

4. No person, firm or corporation shall throw, or permit to be thrown or deposited in any sewer opening or receptacle connected with the public sewer system or individual on-site sewage disposal system, any garbage, offal, dead animals, bones, ashes, cinders, rags, or any other material or thing excepting feces, urine and necessary toilet paper, household liquids.

5. No person shall discharge or cause to be discharged any sanitary sewage to any storm sewer.

6. No person shall discharge or cause to be discharged into the public sewer or individual on-site sewage disposal system or building sewer the following described substances, materials, water or waste:

a) Sewage at a temperature in excess of sixty degrees (60 degrees) Celsius;

b) Sewage containing any inflammable or explosive matter, and without limiting the generality of the foregoing, gasoline, benzene, naphtha, fuel oil, acetone, or other solvents;

c) Any quantity of matter capable of obstructing the flow in or interfering with the proper operation of any part of the sewage works, and without limiting the generality of the foregoing, any such quantity of ashes, cinders, garbage, sand, straw, mud, shavings, metal, glass, rags, feathers, plastics, wood or cellulose;

d) Sewage that may cause a nuisance, and without limiting the generality of the foregoing, sewage containing hydrogen sulphide, carbon disulphide, ammonia, trichlorethylene, sulphus dioxide, formaldehyde, chlorine, bromine or phyridene, in such quantity that an offensive odor could emanate from the sewage works or could cause a nuisance;

e) Sewage having a ph less than 5.5 or greater than 5.9 [sic] or which, due to its nature or content, becomes less than 5.5 or greater than 9.5 [sic] during transmission to a sewage treatment plant;

f) Sewage which exerts or causes:

(i) unusual concentrations of inert suspended solids (such as, but not limited to, Fuller's earth, lime slurries, and lime residues) or of dissolved solids (such as, but not limited to, sodium chloride and sodium sulphate);

(ii) excessive discoloration (such as, but not limited to dye wastes and vegetable tanning solutions);

(iii) unusual BOD, chemical oxygen demand, or chlorine requirements in such quantities as to constitute a significant load on the sewage treatment works;

(iv) unusual volume of flow or concentration of wastes constituting "sludge" as defined herein.

g) The contents of septic tanks.

h) Radioactive materials except as may be permitted under the Atomic Energy Control Act, R.S.C. 1952, Chapter II and amendments thereto and regulations thereunder.

i) Storm run-off, sewage derived from the drainage of lands or roofs, water used for cooling purposes or any other unpolluted wastewaters.

j) Without limiting any of the foregoing, no person shall discharge or cause to be discharged any waters or wastes containing substances which are not amenable to treatment or reduction of the sewage treatment processes employed, or are amenable to treatment only to such degree that the sewage treatment plant effluent cannot meet the requirements of other agencies having jurisdiction over discharge to the receiving waters.

7. If any water or wastes are discharged, or are proposed to be discharged to the public sewers or individual on-site sewage disposal systems which waters contain in substance or process the characteristics enumerated in Part 6, Section 6 of this By-Law, the Municipality may do any or all of the following:

a) Reject the wastes;
b) Require pretreatment to an acceptable condition for discharge to the public sewers or individual on-site disposal systems;
c) Require control over the quantities and rates of discharge;
d) Require payment to cover the added cost of handling and treating the wastes not covered by existing taxes or sewage charges.

8. If the Municipality requires the pretreatment or equalization of waste flows, the design and installation of the plants and equipment shall be subject to the review and approval of the Municipality and subject to the requirements of all relevant Federal and Provincial Statutes and Regulations.

9. Where preliminary treatment or flow equalization facilities are provided for any waters or wastes, they shall be maintained continuously and satisfactorily in effective operation by the Owner at his expense.

10. Whenever the Inspector considers it is necessary, he or they shall require any person who is the owner of land which is used for industrial or commercial purposes and which is connected to a public sewer or individual on-site sewage disposal system to provide grease, oil, and sand inceptors in order to provide for the proper handling of liquid wastes containing grease in excessive amounts, or any inflammable waste, sand, or other harmful ingredients.

All owners of garages, service stations, car wash operations and similar business establishments shall provide approved types of inceptors for oil, grease, soap and similar products. All inceptors shall be of a type and capacity approved by the Inspectors, and shall be located so as to be readily and easily accessible for cleaning and inspection. Grease and oil inceptors shall be of substantial construction, watertight and equipped with easily removable covers which, when bolted in place, shall be gas-tight and watertight.

11. When required by the Municipality, the Owner of any property served by a building sewer carrying industrial waste shall install a suitable control manhole, together with such necessary meters and other appurtenances in the building sewer to facilitate observation, sampling and measurement of the wastes. Such manholes, when required, shall be accessible and safely located, and shall be constructed in accordance with plans approved by the Municipality. Manholes shall be installed by the Owner at his expense and shall be maintained by him so as to be safe and accessible at all times.

PART 7: FINANCES

1. Every owner of land within the Wastewater Management District Area which is serviced by a public sewer or is fronting on any street or highway within the Municipality of the District of Guysborough, which street or highway has a public sewer installed (as determined by Council pursuant to this By-Law), or which is serviced by an individual on-site sewage disposal system, shall pay to the Municipality a capital charge per equivalent unit. The capital charge shall be the total cost of completing the project, less any amounts funded by Provincial and/or Federal Governments and/or any amount paid by the Municipality from municipal sources to be determined by Council pertaining to the Capital Project. The amount so determined shall be the cost of the project to the property serviced within the Wastewater Management District Area. This amount shall be divided by the total amount of equivalent units in the Wastewater Management District Area served by the system to determine the charge per equivalent unit. The charge for each serviced property shall be determined by multiplying the capital charge per equivalent unit by the number of equivalent units

for the property determined in accordance with Section 3 herein. Council shall determine the capital charge for each area covered by this By-Law, which capital charge shall be reviewed from time to time by Council. In the event of development of a lot not previously serviced by a public sewer or individual on-site sewage disposal system the cost of connection shall be the capital charge determined hereunder and reviewed by Council from time to time.

2. The Capital charges, including interest, are first liens on the real property and may be collected in the same manner as other taxes.

3. Annual Installments: Annual installments for payment of Sewer Capital Charges may be made over a period not exceeding ten (10) years starting from the beginning date of October 1, 2001. The annual installment shall be determined by dividing the total capital charge of the serviced property by ten. Annual bills shall be mailed out yearly following the beginning date. Interest is payable annually on the entire amount outstanding and unpaid, whether or not the owner has elected to pay by installments, as follows. Interest will be calculated monthly onthe entire amount outstanding and unpaid at a rate of 9.25 percent. The monthly interest rate shall be one-twelfth of 9.25 percent.

4. The owner of any property which is served by a public sewer system, clustered sewage disposal system or individual on-site sewage disposal system within the Wastewater Management District Area shall pay an annual maintenance charge. The basic annual maintenance charge shall be calculated based on an amount budgeted by Council to be the amount required to maintain and operate the system for the year plus an amount to be set aside as a reserve for future capital expenditures and/or major repairs to the system. Once the budget has been determined, the charge per equivalent unit shall be determined by dividing the estimated budget amount for maintenance and operation by the total number of equivalent units in the Area within the Wastewater Management District Area served by the systems. The annual maintenance charge for each property shall then be determined by multiplying the basic annual charge by the number of units for the property determined in accordance with Section 3.

5. The Every owner of land which is serviced by the system shall be assigned cost based on equivalent units. The equivalent unit shall be based on the following:

TYPE OF USE	IMPERIAL GALLONS	UNITS
1. Single Family Residence	200	1
2. Apartment (self-contained)	200	1
3. Office Building	10 (per employee)	See Note 1 below
4. Church or Hall	200	1
5. Senior Citizen's Complex	100 (per apartment)	See Note 1 below
6. Rest Home	100 (per bed)	See Note 1 below
7. Hospital	150 (per bed)	See Note 1 below
8. Campground	50 (per site)	See Note 1 below
9. Hotel/Motel with Bath	75 (per unit)	See Note 1 below
10. Hotel/Motel Housekeeping Unit	100 (per unit)	See Note 1 below
11. Hotel without Bath	50 (per unit)	See Note 1 below
12. Laundromat	85 (per washer)	See Note 1 below
13. Restaurant	30 (per seat)	

Note 1: Total flows for this use shall be calculated based on the flow given times the appropriate number of employees, apartments, beds, sites, units, washers or seats depending on the type of use. The number of equivalent units is calculated by dividing the above total flow by 200. When the number of units calculated is less than one (1) at any single location, the number of equivalent units assigned to that location shall be one (1).

6. Every charge or tax imposed under the provisions of this By-Law shall constitute a first lien upon the real property, and may be collected in the same manner as other taxes and, at the option of the Treasurer, be collectable at the same time, and by the same proceedings, as taxes, pursuant to Section 81 of the Municipal Government Act.

7. Each property or owner thereof is liable for the entire cost of the building sewer from his property to the street line or individual on-site sewage disposal system.

8. An official appointed by Municipal Council shall keep an account of the cost incurred in installing, laying and construction of any sewer and on its completion shall file in the office of the Municipal Clerk:

  a. A certificate of the costs of the work;

  b. A statement of the equivalent units for each property with the name of the Owner thereof.

9. The sewer capital charge shall be payable within thirty (30) days from the date of billing by the Municipality.

10. The Municipal Council shall notify the Owner of the basis of the sewer capital charge assessment to him and the account payable.

11. The annual maintenance charge shall be due and payable on the date for payment of general rates in each year or a date to be determined by Council.

12. Any and all charges made pursuant to the Wastewater Management District By-Law are in lieu of any charges made pursuant to the Sewer By-Law for the Municipality of the District of Guysborough and no one will be liable to pay a charge under both.

PART 8: POWERS AND AUTHORITIES OF INSPECTORS

1. The Municipality, its servants and agents may enter on any property within the Wastewater Management District to repair, upgrade or replace a public or private wastewater system and may, as set out in this By-Law, charge any or all of the costs to the owners of the property served by the system.

PART 9: PENALTIES

1. Any person found to be violating any provision of this By-Law shall be subject to prosecution, and upon conviction shall be subject to a penalty not exceeding One Thousand Dollars ($1,000.00).

PART 10: REPEALING

1. All former Wastewater Management District By-Laws, which include lands contained in Schedule A, passed by the Council are hereby repealed and this By-Law substituted therefore.

On-site and Decentralized Wastewater Treatment System Codes

Most states in the United States have an environmental or health code to regulate the design of on-site and decentralized wastewater systems. Typically, regulations governing systems below a certain size are prescriptive and regulations governing systems above a certain size, especially for package treatment plants and surface discharging systems, are performance based. States often reflect this in two different sets of regulations.

Some states provide a comprehensive regulatory authority, while others authorize local jurisdictions to pass their own regulations or to pass regulations that supplement state standards.

Model codes are also available for local and state governments. The National On-site Wastewater Recycling Association (NOWRA) is in the process of creating a model performance-based code. NOWRA advocates a performance-based approach with a strong on-going management focus (see www.nowra.org/files/NOWRAAdoptedSept29Paper.pdf).

STATE	STATE REGULATIONS AND TECHNICAL STANDARDS (PARTIAL LIST)
Alabama	On-site Sewage Disposal and Subdivision-On-site Sewage Systems, Water Supplies and Solid Waste Management, Chapter 420-3-1
Alaska	Wastewater Treatment and Disposal Regulation, 18 AAC 72
Arizona	Aquifer Protection Permits, Title 18, Chapter 9, Article 2 and 3
Arkansas	Rules and Regulations Pertaining to Sewage Disposal Systems, Designated Representatives and Installers, Act 402,
Indiana	Residential Sewage Disposal Systems, Rule 410 IAC 6-8.1
California	California has not had statewide regulations and left it to local jurisdictions to establish their own regulations.
Colorado	Guidelines on Individual Sewage Disposal Systems, Chapter 25, Article 10
Connecticut	Technical Standards for Subsurface Sewage Disposal Systems Discharges 5,000 gallons per day or less, Section 19-13-B103, Technical Standards for The Design and Construction of Subsurface Sewage Disposal Systems, Section 19-13-B103 Design of Subsurface Sewage Disposal Systems for Households and Small Commercial Buildings
Delaware	Regulations Governing the Design, Installation, and Operation of On-Site Wastewater Treatment and Disposal Systems
Florida	Florida Administrative Code Standards for On-Site Sewage Treatment and Disposal Systems, Chapter 64E-6
Georgia	On-Site Sewage Management Systems Rules of the Georgia Department of Human Resources, Chapter 290-5-26
Hawaii	Wastewater Systems, Title 11, Chapter 62
Idaho	Individual/Subsurface Sewage Disposal Rules, IDAPA 58, Title 01, Chapter 03 Technical Guidance Manual for Individual and Subsurface Sewage Disposal Systems
Illinois	Private Sewage Disposal, Code Title 77, Chapter I, Subchapter Part 905

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STATE	STATE REGULATIONS AND TECHNICAL STANDARDS *(continued)*
Indiana	Residential Sewage Disposal Systems, Rule 410 IAC 6-8.1
Iowa	On-Site Wastewater Treatment and Disposal Systems, Chapter 69
Kansas	Minimum Design Standards for Design, Construction, and Operation of On-Site Wastewater Systems , Department of Health and Environment, Bulletin 4-2
Kansas	Administrative Regulations, Chapter 28, Article 5; Sewage and Excreta Disposal
Kentucky	Construction Standards for Components of On-Site Sewage Disposal Systems, KAR 10:081 Kentucky On-Site Sewage Disposal Systems Regulation, KAR 10:085
Louisiana	Sanitary Code, Chapter XIII
Maine	Maine Subsurface Wastewater Disposal Rules, 144A CMR 241
Maryland	Sewage Disposal and Certain Water Systems for Homes and Other Establishments in the Counties of Maryland, Where a Public Sewage System is Not Available, Title 26, Subtitle 04, Chapter 02 Water Supply and Sewage Systems in the Subdivision of Land in Maryland, Title 26, Subtitle 04, Chapter 03
Massachusetts	The State Environmental Code Title 5; Minimum Requirements for the Subsurface Disposal of Sanitary Sewage, 310 CMR 15.00
Michigan	Regulatory Structure for Sanitary Sewage
Minnesota	Individual Sewage Treatment Systems Program, Chapter 7080
Mississippi	Individual On-Site Wastewater Disposal , Regulation 2.0
Missouri	Missouri Laws for On-Site Disposal Systems, Department of Health an Senior Services Rules
Montana	Montana Standards for On-Site Subsurface Sewage Treatment Systems, Circular DEQ-4
Nebraska	Rules And Regulations For The Design, Operation And Maintenance Of On-Site Wastewater Treatment Systems, Title 124, Department Of Environmental Quality
Nevada	Regulations Governing Individual Sewage Disposal Systems Chapter 444
New Hampshire	Subdivision and Individual Sewage Disposal System Design Rules, Chapter Env. - Ws 1000
New Jersey	Standards for Individual Subsurface Sewage Disposal Systems, N.J.A.C. 7:9A-1
New Mexico	Liquid Waste Disposal Regulations, 20.7.3 NMAC
New York	Wastewater Treatment Standards Individual Household Systems, 10NYCRR Appendix 75-A
North Carolina	North Carolina Rules for Sewage Treatment and Disposal Systems, Article 11, Chapter 130A of the NC General Statutes Rules/ 15A NCAC 18A.1984 et seq.
North Dakota	North Dakota State Plumbing Code Individual Sewage Disposal Systems for Homes and Other Establishments Where Public Sewage Systems Are Not Available, Chapter 62-03.1-03
Ohio	Household Sewage Disposal Rules, Ohio Administrative Code Chapter 3701-29
Oklahoma	Individual and Small Public On-Site Sewage Disposal Systems, OAC 252:641

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STATE	STATE REGULATIONS AND TECHNICAL STANDARDS *(continued)*
Oregon	Oregon Administrative Rules for On-Site Sewage Disposal, Chapter 340, Division 71
Oregon	Administrative Rules for On-Site Sewage Disposal, Chapter 340, Division 73
Pennsylvania	Title 25 Environmental Resources, Chapter 71, 72 and 73 Standards for Sewage Disposal Facilities
Rhode Island	Rules and Regulations Establishing Minimum Standards Relating to Location, Design, Construction and Maintenance of Individual Sewage Disposal Systems
South Carolina	Individual Sewage Treatment and Disposal Systems, R.61-56
South Dakota	Individual and Small On-Site Wastewater Systems, Chapter 74:53:01
Tennessee	Regulations to Govern Subsurface Sewage Disposal Systems, Chapter 1200-1-6
Texas	Construction Standards for On-Site Wastewater Treatment, Chapter 285
Utah	Individual Wastewater Disposal Systems, Utah Administrative Code, R317-501 to R317-513
Vermont	Environmental Protection Rules, Chapter 1, Small Scale Waste water Treatment and Disposal Rules
Virginia	Sewage Handling and Disposal Regulations
Washington	On-Site Sewage Systems Regulations On-Site Sewage Disposal, Chapter 246-272 WAC (also a series of guidelines documents for Dosing Systems, Pressure Distribution Systems, Mound Systems, Re-circulating Gravel Filter Systems, Intermittent Sand Filters, Packed Bed Filters, Subsurface Drip Systems, Stratified Sand Filter Systems, and other technologies.
West Virginia	Design Standards for Individual and On-Site Sewage Systems, Title 64, Series 47 Sewage System Rules, Title 64, Series 9
Wisconsin	Private Sewage, Wisconsin Administrative Code Chapter Comm 83, 85, and 87, Systems
Wyoming	Septic Tank and/or Soil Absorption Systems, Water Quality Rules and Regulations, Chapter XI, Part D

Source: National Small Flows Clearinghouse (www.nesc.wvu.edu/nsfc/nsfc_national_summaries_1.htm) and web sites for each of the cited states.

Glossary

absorption: The incorporation of a substance into another substance, such as when sewage effluent is drained into a soil.

adsorption: The adhesion of portions of effluent (or any other material) to soil or other media with which they are in contact.

aerobic and aerobic treatment: Having molecular oxygen (O^2) or oxygen not attached to other atoms. This provides active biological treatment with oxygen-breathing microorganisms.

alternative system: A system other than a septic tank, supplemented with an in-ground leachfield.

anaerobic and anaerobic treatment: Lacking molecular oxygen (O_2).This provides for poor or no treatment, except for denitrification (anoxic process).

anoxic process: The anaerobic treatment process where nitrate-nitrogen (NO_3-) is converted biologically to nitrogen gas (N_2).

aquifer: Groundwater that can be economically used.

biochemical oxygen demand (BOD): The amount of oxygen that will be used in a natural system to break down organic materials/pollutants, determined by a standardized testing protocol.

biomat: The biological mat consisting of biological growth and inorganic material at a leachfield's soil/stone interface. Also referred to as clogging layer.

blackwater: Effluent from toilets.

cluster or community system: A sewage treatment and disposal system that serves two or more homes or other waste generators.

composting toilet: A self-contained toilet to compost human waste.

constructed wetlands: Artificial wetlands used to treat effluent using wetland processes. One of the most common innovative systems in many parts of the world.

decentralized sewage disposal: Sewage that is treated using natural processes on-site or in cluster sewage disposal systems.

denitrification: Biochemical reduction (generally under anaerobic conditions) of nitrate-nitrogen (NO_3-) or nitrite-Nitrogen (NO_2 -) to gaseous molecular nitrogen (N_2).

fecal coliforms: Bacteria from the feces from warm-blooded animals (especially E. coli). Such bacteria are "indicator bacteria" because they indicate the potential for pathogens, even though fecal coliforms are generally not pathogens.

grey water: Effluent from showers and other nontoilet waste sources.

Long-Term Acceptance Rate (LTAR): The long-term rate at which effluent can drain into a leachfield once a biological mat has formed and the system reaches a steady state.

nitrification: Biological oxidation (under aerobic conditions) of ammonium to nitrate-nitrogen (NO_3-) or nitrite-nitrogen (NO_2-) .

on-site sewage disposal; on-site sewage treatment and disposal systems (OSTDS); on-site wastewater treatment system; septic tank-soil absorption system (ST-SAS); septic system; wastewater soil absorption system (WSAS); decentralized wastewater systems: Sewage treatment systems that use natural and mechanical processes on the site of the individual waste generator. Typically, these systems consist of a septic tank supplemented with some type of treatment system that ultimately discharges sewage into the soil. [*All of these terms are used to describe the same thing. This generality can cause confusion and makes keyword searches when doing research more difficult.*]

package plant: A miniature aerobic sewage treatment plant for a development or large facility, typically privately run.

pathogens: Disease-causing microorganism, including viruses, bacteria, parasitic protozoa and worms, and prions.

pressurized dosing: A system that pumps or siphons a set volume of effluent to a treatment system under pressure.

prions: Proteins much smaller than viruses believed to cause wasting brain disease.

septage: Solids and scum pumped from septic tanks by septage haulers as routine maintenance of septic tanks, often disposed of at centralized sewage treatment plants.

Septic Tank-Sewage Effluent Pump (STEP): An alternative to very expensive conventional gravity sewerage systems and sewage grinder pumps. A STEP system consists of a septic tank installed at each house or waste generator. The effluent leaving the septic tank does not contain solids, allowing it to be pumped more readily and less expensively than in a conventional sewerage system.

sewerage: The system of pipes that collects sewage from individual generators and delivers it to a centralized sewage treatment facility.

soil texture: The make-up of soil by mineral particle size, including sand (larger particles 0.05 to 2.0 mm), silt (smaller particles 0.002 to 0.05 mm), clay (very small particles <0.002 mm in diameter), and combinations of these materials. Texture does not refer to chemical composition of the soil. Larger materials may include gravel.

sole source aquifer: An aquifer that is the only source of potable water for an area.

solids: In the effluent stream, both organic and inorganic solids.

suspended solids: Silt-sized organic matter that is initially suspended in water but could eventually settle. Dissolved solids, such as nutrients, are dissolved into the water.

variable grade sewer (*see also* ***STEP system***): A sewer line that, after solids are removed, can have varying grades, making it much less expensive to install than conventional gravity or pumped sewerage.

virus: A very small organism too small to see with a light-microscope that lives live in a host cell. They can be very hardy and long-lived.

waste management districts An entity managing sewage waste, often including decentralized systems.

Source: Consortium of Institutes for Decentralized Wastewater Treatment 2002 and the authors

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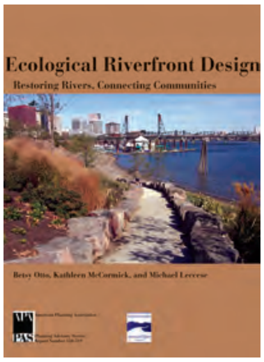
# of special interest



Ecological Riverfront Design

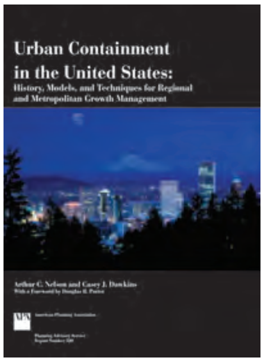
PAS 518/519. Betsy Otto, Kathleen McCormick, and Michael Leccese. 2004. 168 pp.

This report offers a new vision for the nation's urban riverfronts. It provides a set of planning and design principles that will allow communities to reclaim urban rivers in the most ecologically sound and economically viable manner possible. In addition to providing an overview of the ecological fundamentals of riverfront development and offering ecologically sound site design guidelines, the report describes the many economic benefits of riverfront reclamation: tourism, recreation, flood control, improved water quality, increased property values.

Urban Containment in the United States

PAS 520. Arthur C. Nelson and Casey J. Dawkins. 2004. 130 pp.

Growth boundaries, service limits, and priority growth areas are meaningless without effective methods of implementation. Urban containment is a set of tools that can turn a line on a map into actual sustainable development. This report explores urban containment as a framework that regions and communities can use for managing growth. The authors review the history and central characteristics of urban containment, evaluate more than 100 urban containment plans, and present a four-framework typology. They also offer case studies of each of the four frameworks and summarize some of the implications for planners.



Planning for the Unexpected

PAS 531. Laurie Johnson, Laura Dwelley Samant, and Suzanne Frew. 2005. 104 pp.

Typical plans include only about half of the elements necessary for a safe, hazard-resistant community. How does your plan stack up? Does it manage environmental, capital, economic, social, and institutional risks? Can it adapt to emerging risks? This report describes the tools planners have to identify and manage risks related to land use. These tools include many common planning approaches such as comprehensive or general plans, specific or area plans, zoning ordinances, subdivision regulations, building codes, capital improvement plans, budgets, and environmental impact reports. This report demonstrates that these familiar techniques can be used to better screen for risks, reduce many risks to acceptable levels, and control risks before they become unmanageable.

Integrating Planning and Public Health

PAS 539/540. Marya Morris, ed. 2006. 132 pp.

Is the form of American cities to blame for the shape of Americans? With obesity rates climbing ever higher, planners are reconsidering how the built environment affects public health—not only obesity, but also asthma, cardiovascular disease, water quality, air pollution, pedestrian safety, and mental health. This report examines collaborations between planners and public-health professionals committed to building healthy communities. It outlines the five strategic points of intervention at which planners and public-health professionals can coordinate their efforts: visioning and goal setting, plans and planning, implementation tools, site design and development, and public facility siting and capital spending. Case studies illustrate the specific tools—including health impact assessments—used in such collaborations. It also examines the role of universal design in creating healthy communities.

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