Decentralized Water Resources:

Answers to the Most Frequently Asked Questions

A Guide to the Research and Products from the Decentralized Water Resources Project

Decentralized Water Resources Collaborative

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A Guide to Research and Products from the Decentralized Water Resources Collaborative

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Tetra Tech, A Green Footprint LLC

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About the Decentralized Water Resources Collaborative

The Decentralized Water Resources Collaborative (DWRC), formally known as the National Decentralized Water Resources Capacity Development Project (NDWRCDP), is a cooperative effort funded by the U.S. Environmental Protection Agency (U.S. EPA) to support research and development on decentralized wastewater and stormwater systems. The DWRC is committed to advancing knowledge, science, and training related to decentralized systems to build the capacity of organizations and individuals to appropriately implement them.

The DWRC was established to improve the capacity of electric utilities, water and wastewater utilities, municipalities, engineers, contractors, regulators, and other public and private entities to respond to the increasing complexities of and expanding need for decentralized wastewater and stormwater systems. The DWRC achieves this by defining and carrying out research that addresses critical knowledge and information gaps in the decentralized wastewater and stormwater treatment fields.

Advancing the field of decentralized management requires collaboration among engineers and technical specialists and educators, regulators, managers, and others with decision-making and leadership roles in water infrastructure. The DWRC has sponsored more than 70 projects since 2000. The DWRC carries out its mission by conducting integrated research in three broad topical areas:

- Environmental science and engineering;
- Management, economics, and policy; and
- Training and education.

The Decentralized Water Resources Collaborative is a collaborative effort of the following organizations:

- Coalition for Alternative Wastewater Treatment (CAWT)
- Consortium of Institutes for Decentralized Wastewater Treatment (CIDWT)
- Electric Power Research Institute (EPRI)
- National Onsite Wastewater Recycling Association (NOWRA)
- National Rural Electric Cooperative Association (NRECA)
- Water Environment Research Foundation (WERF)

This Frequently Asked Questions (FAQs) guide is not intended to be a comprehensive guide to decentralized systems, but rather to show how information from the DWRC effort addresses key questions, problems, and topics in the decentralized wastewater and stormwater fields. It also serves as a navigational tool to point users to specific reports, products, tools, and resources developed by the DWRC. Although DWRC research forms the basis for the FAQs that follow, links to other relevant sources of information also are provided where applicable. For all products from the DWRC, visit www.decentralizedwater.org.

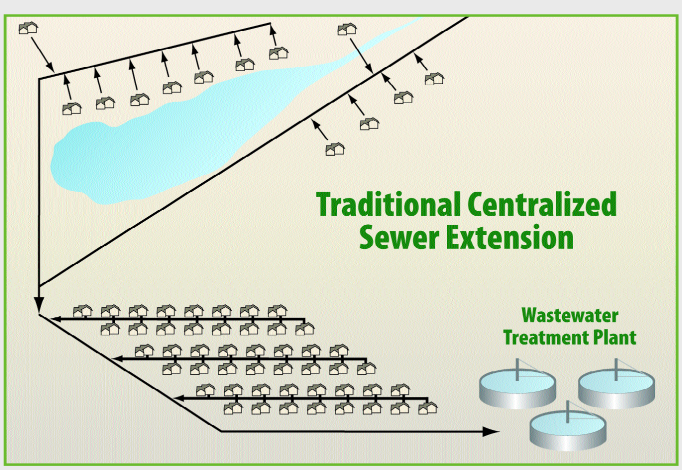
Are decentralized systems different than traditional municipal systems?

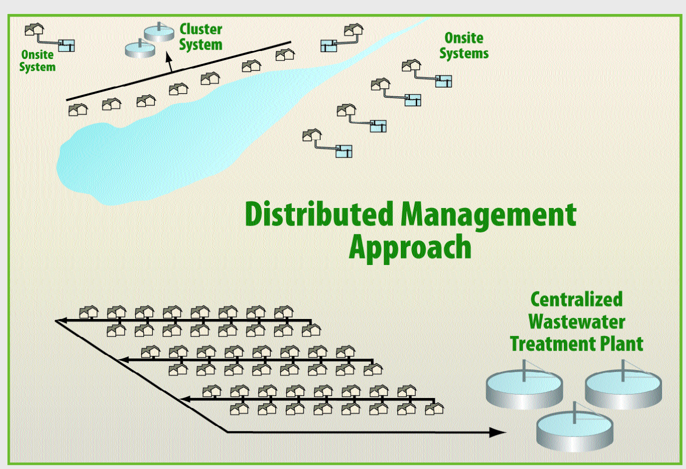
Yes. Traditional sewer and stormwater systems typically collect and convey stormwater and wastewater collected from relatively expansive areas long distances to large centralized treatment plants. By contrast, decentralized systems are smaller wastewater and stormwater systems located in close proximity to the source of water being managed. Treating water near its source reduces the energy demand associated with conveyance and promotes localized reclamation and reuse of treated water. When used to recharge local aquifers, decentralized systems help keep local water cycles in balance.

To establish consistent terms for describing these systems, the DWRC developed the Decentralized Wastewater Glossary. The glossary describes decentralized wastewater management as "wastewater treatment systems for collection, treatment, and dispersal/reuse of wastewater from individual homes, clusters of homes, isolated communities, industries, or institutional facilities, at or near the point of waste generation". The term "decentralized system" has been expanded to include stormwater management systems that are located close to sources of storm runoff, providing similar localized treatment and reuse options.

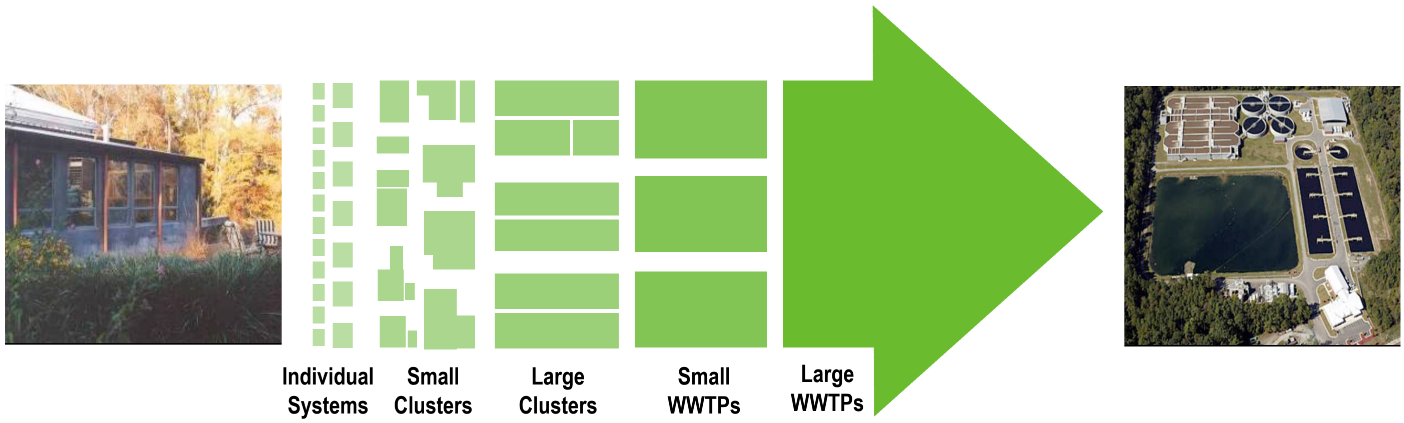
■ Are there differences between onsite systems, decentralized systems, cluster systems, and distributed management?

Yes. *Onsite wastewater treatment systems* are defined as "wastewater treatment systems relying on natural processes and/or mechanical components to collect and treat sewage from one or more dwellings, buildings, or structures and disperse the resulting effluent on property owned by the individual or entity" served by the system. *Cluster systems* are designed to serve two or more wastewater-generating dwellings or facilities with multiple owners, may include both public and private ownership and management responsibilities, and may be developed in conjunction with a land-use or development master plan.





The Wastewater Management Continuum



WWTP = Wastewater Treatment Plant

Both onsite and cluster systems are examples of decentralized systems.

Distributed management refers to the integrated management of systems in many locations, which may span a range of scales and can include a combination of individual onsite or on-lot, through cluster and small community, to larger centralized systems. The U.S. EPA and others promote coordinated, integrated management of all wastewater systems, regardless of scale and location, as an ideal approach to effectively and efficiently deliver water services to users and protect public health and environmental quality.

■ Are there barriers that hinder the consideration of decentralized systems equally with centralized systems? If so, how are those barriers being addressed and how can I help overcome those barriers in my local community?

Yes, there are barriers. Several DWRC projects have identified and evaluated reasons why decentralized approaches are not considered and used more widely compared with centralized approaches.

Overcoming Barriers to Evaluation and Use of Decentralized Wastewater Technologies and Management identifies several significant barriers that prevent engineers from considering decentralized options and evaluates the influence engineers have in overcoming them. These barriers include:

- Financial rewards for engineers recommending and designing centralized systems (and lack of reward for using decentralized systems);
- Lack of knowledge among engineers about decentralized systems and approaches;
- Regulatory system that favors centralized over decentralized systems; and
- Lack of systemic, integrated water management considerations in wastewater planning and design.

New Approaches in Decentralized Water Infrastructure explores the drivers for and impediments to change in the fundamental ways that water is managed. Important strategies for more sustainable, decentralized water infrastructure include:

- Incorporating water concerns into the more widely understood green building movement;
- Funding of high-profile community demonstration projects that show how more sustainable water systems can be implemented;
- Creating new interactions among academics, entrepreneurs, engineers, activists, public bureaucrats, managers, and the public around sustainable water infrastructure issues; and
- Shifting to a more systems-oriented, integrated infrastructure approach, which helps close the loop on resource cycles including water, nutrients, carbon, energy, and metals, while recovering value and creating revenue streams that are net positive.

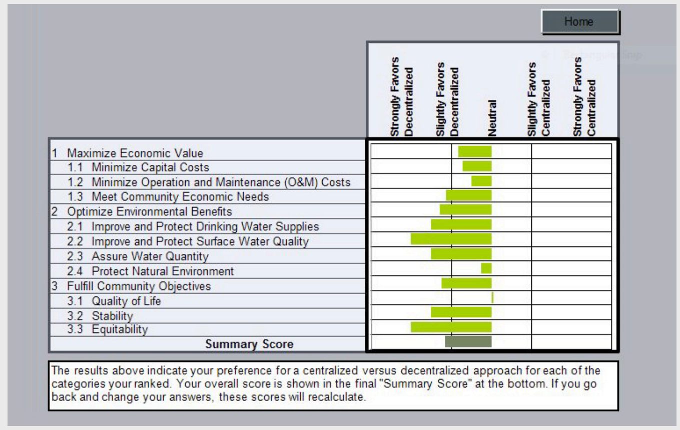
Many DWRC projects indicate a need for a serious restructuring of American water institutions and policies, which could include integrating planning, funding, and regulations across the currently segmented fields of drinking water, stormwater, and wastewater; an expanded role for the private sector in technology development, systems management, and finance; improved community engagement in water infrastructure decision-making; and more capable management that stimulates and rewards innovation and reform.

At a local level, there are many things that both professionals and other community stakeholders, including the public, can do to promote sustainable decentralized approaches. Non-Governmental Organizations (NGOs): Enhancing Their Role in Advancing the New Water Infrastructure Paradigm explores the education and training needs for local NGOs to fully consider decentralized options and outlines how they can collaborate more effectively with industry, engineers, and utilities. Update of the Advanced On-Site Wastewater Treatment and Management Market Study provides useful information on the status of regulations, management, technology use, funding, training programs, and research and demonstration projects in each of the fifty states.

■ How would I find out if decentralized systems can be used effectively in my community?

Traditional engineering analyses undertaken by communities following regular state and local funding processes often focus on conventional centralized approaches for meeting water and wastewater treatment needs. These analyses often do not thoroughly evaluate all of the costs and benefits associated with other potential options such as decentralized, hybrid centralized-decentralized, or incremental project implementation approaches, if such approaches are considered at all. When considered across the triple bottom line of environmental, economic, and societal benefits, professionally managed decentralized water infrastructure systems are often preferable to centralized approaches. To help address the need for more equitable analyses, the DWRC has developed several different resources to help stakeholders and professionals evaluate where and how decentralized water systems can work effectively and efficiently in their communities.

When to Consider Distributed Systems in an Urban and Suburban Context helps communities determine whether



The WERF Decentralized Wastewater Stakeholder Decision Model helps stakeholders assess the ability of centralized or decentralized systems to meet their objectives.

they should consider using a decentralized approach, even when traditionally used centralized alternatives are available. The project developed several guidance papers, 20 case studies, and an Excel-based decision-support model that help stakeholders assess the ability of centralized or decentralized systems to meet their community-specific sustainability objectives. Case Studies of Economic Analysis and Community Decision-Making for Decentralized Wastewater Systems helps decision-makers facing wastewater system choices to understand the implications of different options. These case studies show how communities can consider and evaluate the benefits and costs of wastewater facility options across various scales (onsite, cluster, or centralized) in monetary or other terms, and examines the driving issues, motivations, and decision-making methods stakeholders have used in choosing their systems. Methods for Comparison of Wastewater Treatment Options studied water infrastructure decision-making and evaluated environmental impact assessment, open wastewater planning, and life-cycle assessment tools that can be used to better capture the full monetary and non-monetary costs of different wastewater alternatives. Performance and Costs for Decentralized Unit Processes provides guidance for a uniform approach to facilitate comparisons of performance and cost associated with various decentralized wastewater technology choices and management options, leading to a better-informed decision-making process. The Cluster Wastewater Systems Planning Handbook outlines a comprehensive wastewater management planning process that enables communities and property owners to assess where and how cluster systems are appropriate. This process enables the development of an optimized management plan using four steps: (1) collecting data and preparing a community profile; (2) defining needs; (3) screening alternatives and developing a final, preferred solution; and (4) developing a management and implementation plan.

Community engagement is critical to the success of any wastewater treatment project. Expanding Communication in Communities Addressing Wastewater Needs provides communications tools that small communities can use to improve participation in decision-making and increase the chance of a successful outcome.

Have decentralized systems been proven to be sustainable, long-term water infrastructure solutions that can meet the triple bottom line of environmental, economic, and societal benefits for local communities and the United States?

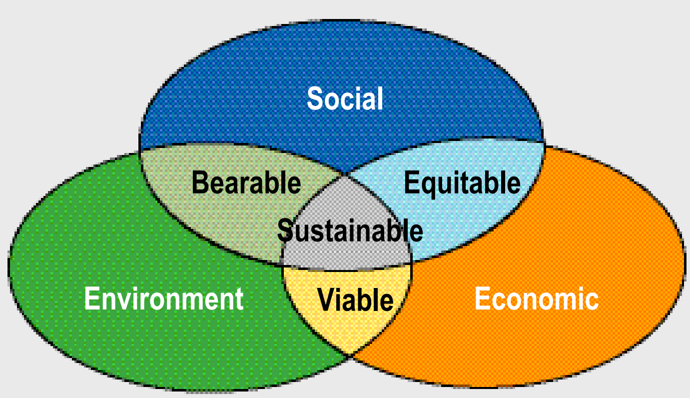
Yes, several DWRC projects show that decentralized approaches have exceptional triple-bottom-line benefits when properly implemented and managed. Reports include Sustainable Water Resources Management, Smart, Clean, and Green: 21st Century Sustainable Water Infrastructure, When to Consider Distributed Systems in an Urban and Suburban Context, and New Approaches in Decentralized Water Infrastructure. The U.S. EPA formally has recognized that decentralized systems are a fundamental element of a sustainable water infrastructure portfolio for the nation by offering funding through the Green Project Reserve (GPR) of the American Recovery and Reinvestment Act (ARRA) of 2009, which singled out projects featuring water and energy efficiency, green infrastructure, and environmental innovation for funding priority.

From an economic perspective, traditional infrastructure projects typically are defined by large, sunk costs that require financing and associated debt service that can be crippling in some jurisdictions if projected user-based revenues (particularly from projected growth) are not realized. A distributed approach that features professional management of decentralized systems allows for more incremental, sustainable, and economically feasible phasing and financing. This approach may include systems built by developers (following community standards and specifications) that are then turned over to a utility for management; or modular systems installed using a phased, pay-as-you-grow approach.

One primary environmental benefit of decentralized systems is their greater treatment efficiency when compared with traditional, centralized approaches. Treatment close to the wastewater or stormwater source and reclaimed water reuse area requires less energy to be used for conveyance. Also, urban reuse retrofits are more feasible and less disruptive than standard approaches where reclaimed water is conveyed from remote treatment plants through dual-piping networks. With traditional, centralized approaches, providing reclaimed water to areas with established infrastructure, such as roads and buildings with existing plumbing systems, can be extremely expensive and disruptive if not impossible. Use of decentralized building- or neighborhood-scale systems, however, makes delivering reclaimed water more economically viable in many cases. Furthermore, use of passive treatment systems with fewer mechanical components and lower operation and maintenance demands is more feasible at the smaller, more localized scales associated with decentralized systems.

Many leading water professionals believe that these new water systems also will provide multiple societal benefits by restoring ecosystems, developing associated "green jobs" needed to manage and install systems, and enhancing recreational and living spaces. Additionally,

Triple Bottom Line of Sustainability



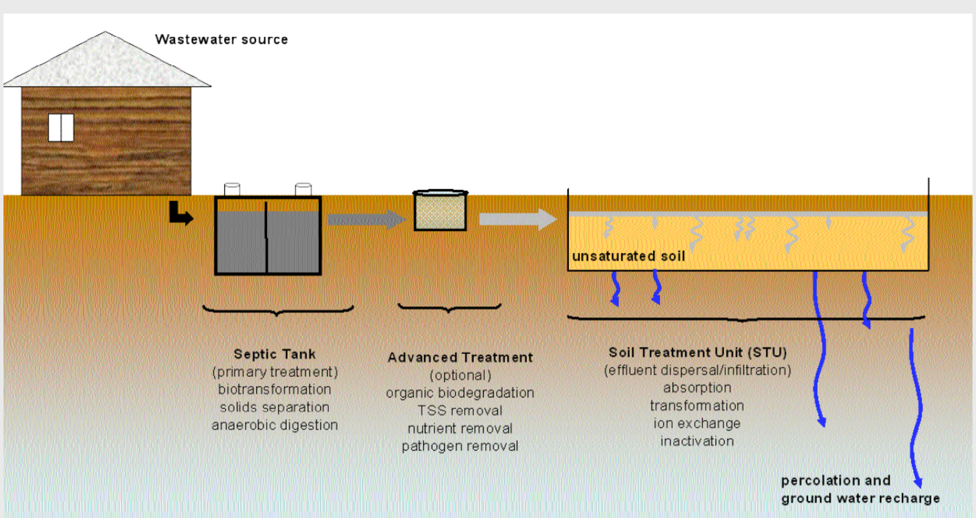
The World Conservation Union (2006) T*he Future of Sustainability: Re-thinking Environment and Development in the Twenty-first Century.* Report of the IUCN Renowned Thinkers Meeting, Jan 29–31.

the use of properly managed decentralized systems can increase the resiliency of a community's infrastructure. Smaller, decentralized systems provide value-added redundancies and diversification, minimizing the potential health and ecological consequences of the loss of treatment during storm events or power failures, which cause substantial and documented environmental damage in centralized systems; or even the potential consequences of system malfunction or sabotage.

Can decentralized systems be used to support smart growth and watershed protection?

Yes. Properly managed decentralized systems are a key tool for supporting growth while protecting water quality. Decentralized wastewater and stormwater systems are particularly valuable tools for implementing watershed management plans. Land application of treated water through reuse or soil dispersal close to its source helps to restore natural hydrology, recharge groundwater resources, and enhance aquatic ecosystems by supporting stream baseflows that may have been disrupted by growth and development. Direct ecological benefits can be realized by using treatment that mimics natural systems (e.g., constructed wetlands) or when high-quality treated effluent is used to restore or enhance surface waters, wetlands, and other aquatic ecosystems. When to Consider Distributed Systems in an Urban and Suburban Context describes several communities that are using distributed systems to help manage growth by defining centralized service areas in their urban cores, while using well-managed decentralized systems to achieve their land-use planning objectives in exurban areas. These communities recognized that extending central system interceptor lines could stimulate growth where it was not desired and opted to use decentralized systems scaled to match zoning as a growth management tool. Other DWRC projects, including Sustainable Water Resources Management, Smart, Clean, and Green: 21st Century Sustainable Water Infrastructure, and New Approaches in Decentralized Water Infrastructure provide examples of the strong connections between decentralized systems, green building, and community land-use planning, among other diverse disciplines.

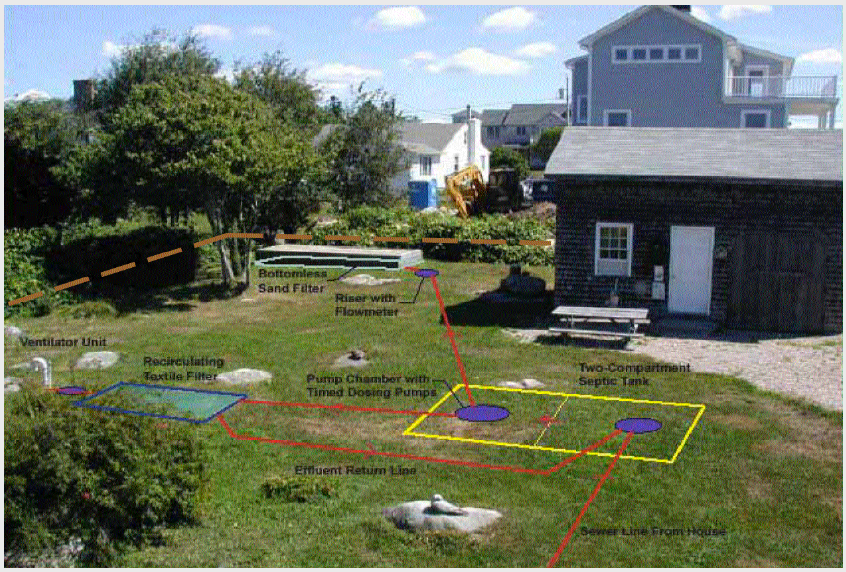
Creative Community Design and Wastewater Management provides a guidance manual for local officials and shows how decentralized technologies can support compact land-use patterns. The manual contrasts standard development layouts using conventional septic systems with creative land-use development patterns using alternative decentralized technologies, comparing outcomes such as construction costs, maintenance needs, visual impact, extent of land disturbance, and environmental impacts using case studies. Pennsylvania Standards for Residential Site Development offers a set of model standards that can be used to update local ordinances to affect sustainable development and decentralized stormwater management.



Schematic of an onsite wastewater treatment system shows how groundwater can be recharged using high-quality effluent from an (optional) advanced treatment unit and soil dispersal system [Source: Water Environment Research Foundation (2009) *State of the Science: Review of Quantitative Tools to Determine Wastewater Soil Treatment Unit Performance*; Water Environment Research Foundation: Alexandria, Virginia].

(TSS = total suspended solids)

The DWRC has sponsored several projects that help support water quality modeling where decentralized wastewater systems are used. Quantifying Site-Scale Processes and Watershed-Scale Cumulative Effects of Decentralized Wastewater Systems presents a methodology for assessing the water quality implications of decentralized systems, including individual and cumulative effects on local water supply wells as well as downstream receiving waters. Modeling Onsite Wastewater Systems at the Watershed Scale: A User's Guide provides guidance for conducting watershed-scale modeling assessments and decision-making associated with potential pollutants of concern from wastewater systems, with a focus on nutrients (nitrogen and phosphorus).



This advanced onsite treatment system serving a house on a small lot shows how exceptional treatment can be provided even when site conditions are limited. [Source: National Decentralized Water Resources Capacity Development Project (2004) *Creative Community Design and Wastewater Management*; National Decentralized Water Resources Capacity Development Project: St. Louis, Missouri.].

Can resources like clean water, energy, and nutrients be recovered using decentralized systems?

Yes. Decentralized systems often include water reuse, using such strategies as rainwater harvesting, stormwater bioretention, and wastewater reclamation. Reclaimed water from decentralized systems is being used for irrigation, toilet flushing, and other nonpotable uses in rural, suburban and urban settings throughout the United States and abroad, reducing the consumption of valuable potable water for these uses.

In addition to water reuse, decentralized wastewater technologies also can be used for the efficient recovery of energy and nutrients. This systemic approach to water and waste management, sometimes referred to as integrated resource management (IRM), can recover value and create revenue streams through recycling and reuse of resources in wastewater. The government of British Columbia, Canada, commissioned an independent report on IRM that examines approaches for local governments across British Columbia to use solid and liquid waste to create energy, reduce greenhouse gas emissions, conserve water, and recover and reuse nutrients.

Traditional, centralized water management practices rely on large amounts of energy to convey and treat water supplies to drinking water quality standards, only to use much of that water to convey wastes to remote, energy-intensive centralized wastewater treatment facilities. One goal of the emerging field of decentralized water management is to design water systems and processes in the most resource-efficient way possible. In some reuse scenarios, it is far more efficient to treat segregated waste streams compared with those that have been commingled. The management of graywater, in particular, is of great interest to communities seeking to reduce their potable water use in a sustainable way. Long-Term Study on Landscape Irrigation Using Household Graywater provides quantitative data and information to better understand the fate and occurrence of graywater chemical constituents and pathogens and their potential effects on soil and groundwater quality.

Sustainable Water Resources Management, Volume 3: Case Studies on New Water Infrastructure Paradigm presents case studies showing how decentralized systems are being used to recover resources from wastes when integrated within existing infrastructure architectures. This report identifies several existing and emerging energy recovery technologies and approaches, including:

- Biofuel production using waste-related resources, such as grease and oil;
- Anaerobic digestion applied at wastewater treatment plants (WWTPs) for recovering biogas from biological wastewater treatment residuals (biosolids or sludge);
- Cogeneration or combined heat and power, for simultaneous production of electrical energy and recovery of byproduct thermal energy;
- Codigestion of wastewater biosolid residuals with other carbon-based organic wastes, such as agricultural waste or municipal solid waste, to generate methane;
- Wastewater effluent heat pumping, where the thermal energy in wastewater is harnessed through heat exchangers and used to help heat or cool buildings; and
- Micro-hydropower where small turbines convert gravitational energy in water to electricity.

Because nutrients are both serious water pollutants and valuable agricultural resources, their recovery and reuse is considered a necessary element of a future sustainable infrastructure approach. Examples of nutrient recovery technologies include:

- Composting, where solid wastes (potentially including wastewater residuals) are mixed with bulking agents and degraded over time to produce a valuable soil amendment;
- Urine separation for processing and use as a nitrogen-rich fertilizer; and
- Various precipitation technologies that convert nitrogen and phosphorus in wastewater streams into solid products that can be used as fertilizers.

Where are decentralized systems being used and what are some emerging and future uses?

Traditionally, decentralized systems were used in areas where centralized public wastewater service was impractical, unnecessary to meet regulations, or simply too expensive such as dispersed villages and rural areas or in developments outside of major urban areas that could be served by cluster systems rather than requiring expansion of municipal central facilities. Several new applications for decen-

In addition to neighborhood cluster treatment systems, Loudoun Water in Loudoun County, Virginia, operates a satellite reclaimed water system as part of their distributed management program.

tralized systems are emerging in areas where traditional centralized service is or could be available but where decentralized systems can better meet community goals.

In When to Consider Distributed Systems in an Urban and Suburban Context, researchers analyzed 20 case studies where distributed infrastructure approaches are being used to provide wastewater service across a range of settings and situations. In some cases, property owners or developers sought to construct green buildings, in part to make the development or building more attractive to future residents or consumers. The Solaire and other buildings in Battery Park City, New York, include building-scale water reuse systems in a highly urbanized area, integrated within the existing centralized sewer infrastructure. In other cases, smaller communities are using distributed systems to preserve their area's unique character by preventing development, population growth, and community change that often is associated with the fiscal pressures represented by larger, traditional centralized sewer or water systems. These communities are able to maintain their social and fiscal independence by avoiding pressures to annex land or connect users to a community's sewer system and by eliminating the large upfront costs and associated debt of building a centralized system. For some underserved communities with marginal to nonexistent wastewater infrastructure or that are in dire need of improvements and cannot afford the higher cost and sophisticated operation and maintenance demands of traditional systems, decentralized systems offer cost-effective solutions that also can qualify for funding support from states and federal sources. Finally, traditional municipal utilities are increasingly relying on distributed systems to provide service to areas outside of their primary service area, which can help build their customer base or to enhance water reuse opportunities in neighborhoods and cities.

Loudoun County, Virginia, and Mobile, Alabama, are excellent examples of communities where both decentralized and centralized wastewater systems are being professionally managed. Additionally, several traditional water utilities are constructing smaller, decentralized satellite wastewater systems for reclaiming water closer to reuse areas.

The DWRC also has sponsored workshops and planning projects that help advance these new directions for sustainable water management in the United States. One project, Long Range Planning for Decentralized Stormwater and Wastewater Treatment Research, outlines an international research agenda supporting integrated and sustainable water infrastructure. Diverse workshop participants committed to implementation of water systems that mimic and work with nature, protect public health and safety, and restore natural and human landscapes as outlined in The Baltimore Charter for Sustainable Water Systems. International Issues and Innovations in Integrated and Decentralized Water Resource Infrastructure: Amendment to International Conference Program Planning Project presents research on and examples of international practices and innovations in decentralized systems.

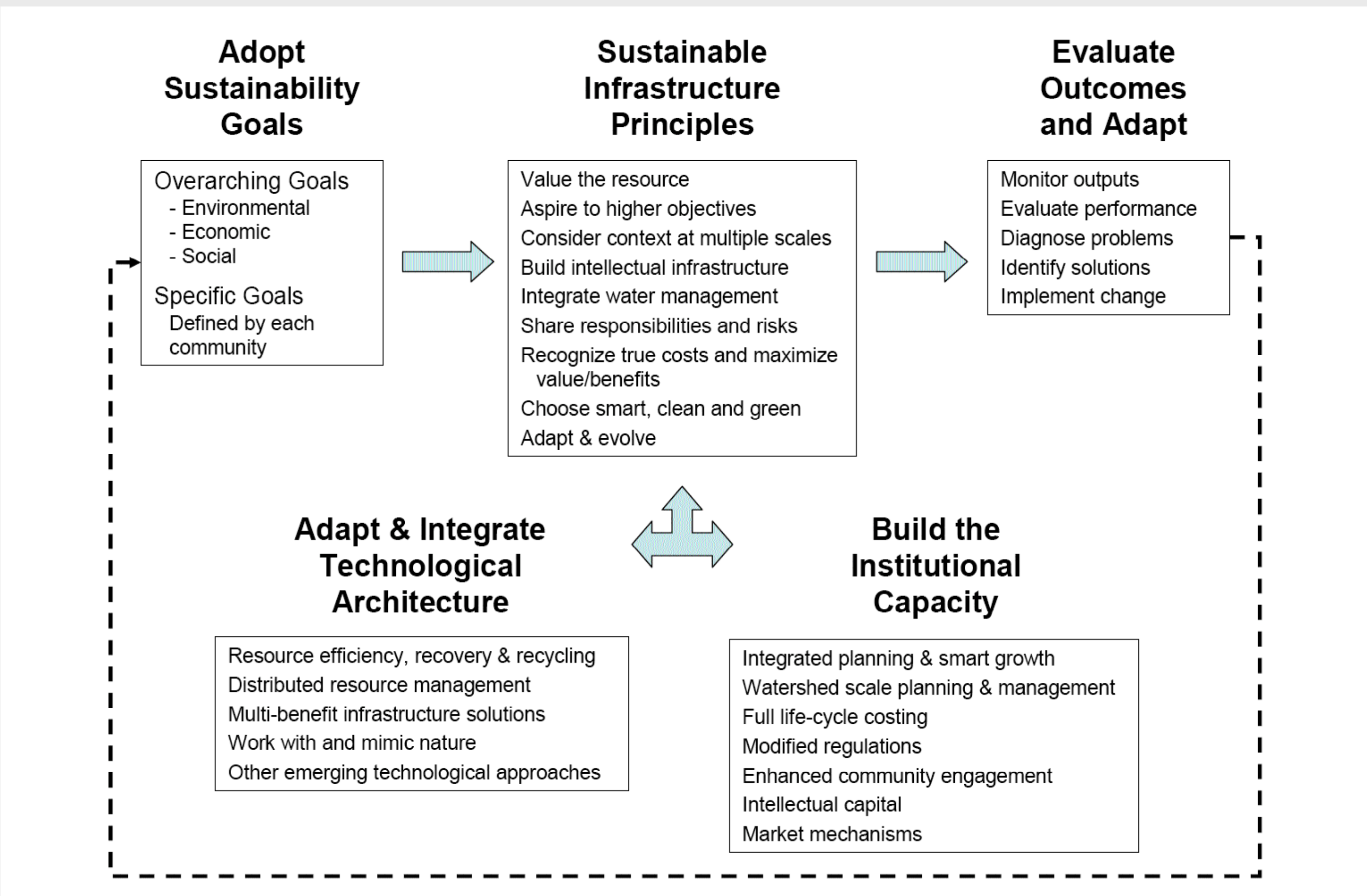
The Solaire, a LEED-certified residential tower in New York City, is a model for the use of a building-scale water reuse system in a highly urbanized area.

These and several other projects, including Sustainable Water Resources Management, Smart, Clean, and Green: 21st Century Sustainable Water Infrastructure, and New Approaches in Decentralized Water Infrastructure, make recommendations for incorporating water concerns into the green building movement and increasing funding for community demonstration projects supporting a new, more sustainable approach for water infrastructure in the United States. The report 21st Century Water Management: Restoring the Commons describes how mismanagement of water is threatening common ecological and societal resources; articulates how new technologies can offer a sustainable path forward; and delineates the new roles that government and civil society will need to play in pricing, regulating, and managing water services.

Additional examples of emerging uses for decentralized systems are documented in Case Studies: Building Blocks for Decentralized Wastewater and the related reports Advanced Decentralized Wastewater Systems: Updated Strategies for Expanded Use, and Update of the Advanced On-site Wastewater Treatment and Management Market Study.

■ What can government officials do to promote sustainable water management in their communities?

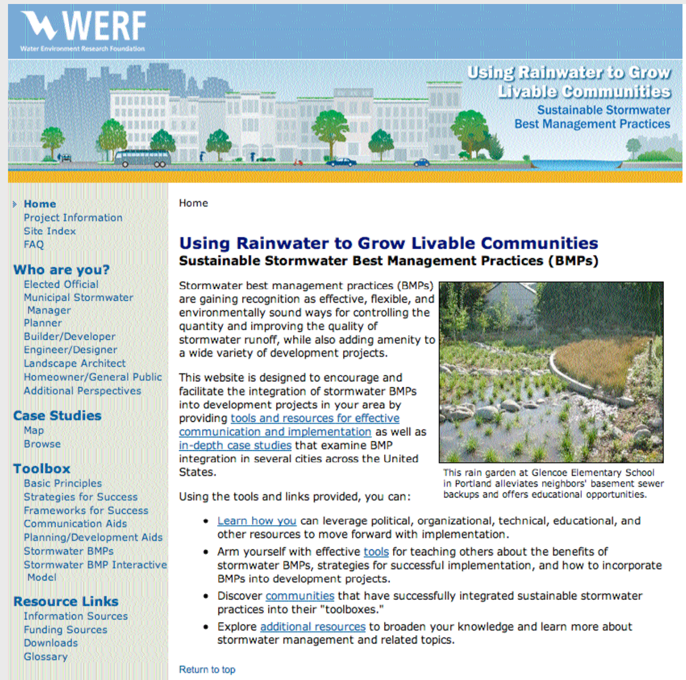
As stresses on water resources—and municipal fiscal resources—increase, sustainable water management will demand the use of innovative technologies that recover and reuse water, mimic and preserve ecological functions, and integrate drinking water, stormwater, and wastewater management. Government officials can promote these approaches in a number of ways.



A shift to more sustainable water management will depend on changes to government policies, management, operations, and procedures, as well as the type and scale of systems used (Source: Electronic Power Research Institute *(2010) Sustainable Water Resources Management, Volume 3: Case Studies on a New Water Paradigm*; Electronic Power Research Institute: Washington, D.C.).

[Sustainable Water Resources Management](#) concluded that although the technologies already exist, a full shift to more sustainable water management will depend on changes to government policies, management, operations, and procedures. Among other things, the report recommends that officials establish a sustainability advisory committee—or expand the role and focus of an existing planning or conservation commission—to help establish community sustainability goals and policies. Communities often begin shifting to sustainable water resource strategies by:

- Pledging to use green building standards, including sustainable water management, in all public buildings or projects;
- Conducting audits of local operations and procedures to identify water conservation, energy efficiency, pollution reduction, and other opportunities;
- Offering credits to homeowners and businesses for installing good practices such as water harvesting or water reuse systems;
- Completing watershed studies to help establish performance standards or targets, and tailor green building policies to what is needed locally; and
- Promoting meaningful community engagement.



One WERF project website (www.werf.org/livablecommunities/) provides tools and resources for effective communication and implementation of best management practices (BMP) for stormwater, including case studies that examine BMP integration in several cities across the United States.

Case studies are a great way to illustrate how communities are promoting sustainable water management approaches to meet multiple community objectives. [Sustainable Water Resources Management, Volume 3: Case Studies on New Water Infrastructure Paradigm](#), [When to Consider Distributed Systems in an Urban and Suburban Context](#), and [Using Rainwater to Grow Livable Communities](#) include useful case studies and other helpful resources.

Many states and local governments actively are promoting water-oriented updates of local comprehensive land use plans to encourage the adoption of measures such as low-impact design (LID) for stormwater management and other water conservation measures. Revising subdivision, zoning, and other land development and building codes to allow or encourage LID and green building practices is often contentious, and the usefulness of technical information available can vary by jurisdiction. To help communities, the Rocky Mountain Land Use Institute maintains an online [Sustainable Community Development Code: A Code for the 21st Century](#). It includes bronze, silver, and gold recommendations for LID and green infrastructure, water conservation, natural resource conservation, climate change, energy efficiency, urban form, and other areas related to sustainable water management.

Formal coordination of local water supply, wastewater, stormwater, and transportation departments' master planning and annual capital improvement planning also can be difficult and contentious. Such coordination requires a shift in how government operations and capital projects are funded, including revising rate structures to better capture the full cost of water service delivery and providing incentives for sustainable practices. [Creative Community Design and Wastewater Management](#) and [Pennsylvania Standards for Residential Site Development](#) provide practical guidance for local officials interested in promoting sustainable decentralized wastewater and stormwater management integrated with land-use planning.

Local stakeholders also should consider professional management of decentralized systems in their communities to enhance the sustainability of their water infrastructure. [Guidance for Establishing Successful Responsible Management Entities](#) provides a resource for people or organizations that are considering managing decentralized wastewater systems.

What scientific and engineering principles are used to design decentralized systems?

Design of decentralized systems relies on many of the same principles as those for traditional, centralized plants but involves a few different approaches. Principles common to both types of systems include hydraulics and fluid statics and dynamics for designing piping and pumping systems, treatment reactors, and storage tanks; and principles of physics, water chemistry, and biology for designing external treatment unit processes.

Although somewhat counterintuitive given their relatively smaller size and often simpler processing steps, design of decentralized systems often involves additional disciplines. Many systems include use of soil or plant and soil systems for wastewater treatment and dispersal. Because engineers have limited ability to modify soils at dispersal sites, soil scientists and hydrogeologists (who study water flow through soils) are key design team members. Site soils are often the most important single unit process in a decentralized system. The natural characteristics of site soils determine how much treatment it will provide, and how much water can be accepted—critical design factors for a soil dispersing decentralized system.

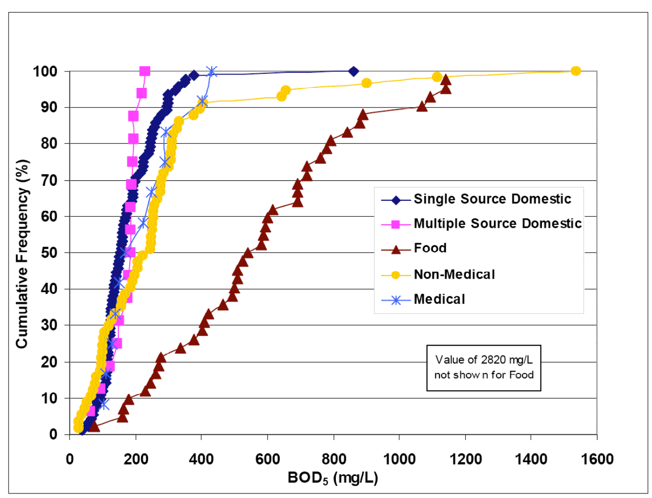
Ecologists, botanists, and horiticulturalists may also influence designs because decentralized systems typically rely on passive treatment processes based on natural, sometimes vegetated, systems. Systems that are part of landscapes or buildings also require extensive integration with a rchitectural disciplines. Planners actively help provide the framework within which decentralized systems can be implemented and managed for the long term through land-use regulations and spending budgets.

Finally, decentralized systems often affect users more than centralized systems. Decentralized systems, typically sited within multiple lots or neighborhoods and requiring land area for soil-based dispersal, are closer to where people live and are more visible than buried sewer conveyance systems or distant plants. Accordingly, public outreach and communication—necessary for any infrastructure project—is particularly important in the planning, design, and management of decentralized systems. Expanding Communication in Communities Addressing Wastewater Needs developed several products that small communities can use to improve participation in wastewater decision-making. The products are compiled in A Starter's Guide for Community-Based Wastewater Solutions and a series of fact sheets to help engage the public in community wastewater management discussions.

■ How can I determine what influent wastewater characteristics should be used for design?

Influent Constituent Characteristics of the Modern Waste Stream from Single Sources helps improve the quality of onsite wastewater system design by characterizing the composition of single residential source raw wastewater and primary treated effluent (i.e., septic tank effluent or STE). An extensive literature review was conducted to assess current knowledge of the composition of single-source raw wastewater, identify key parameters affecting wastewater composition, and summarize information gaps. Field investigations spanning all four seasons in three distinct regions of the United States were also conducted and focused on characterizing conventional constituents, microbial constituents, and emerging organic chemicals.

For systems serving nonresidential facilities, designers should consult reputable engineering texts, EPA guidance manuals, state regulations, and the latest published research. Where possible (e.g., for retrofits and repairs or in cases where similar facilities exist), influent wastewater sampling can be conducted to determine appropriate design values.



Influent Constituent Characteristics of the Modern Waste Stream from Single Sources includes a series of cumulative frequency diagrams (CFDs) to help communicate key statistics on the pollutant characteristics of raw wastewater and septic tank effluent from various sources.

■ What unit processes are used in decentralized wastewater systems, what quality effluent can be expected from various decentralized and distributed system unit processes, and what factors affect treatment performance?

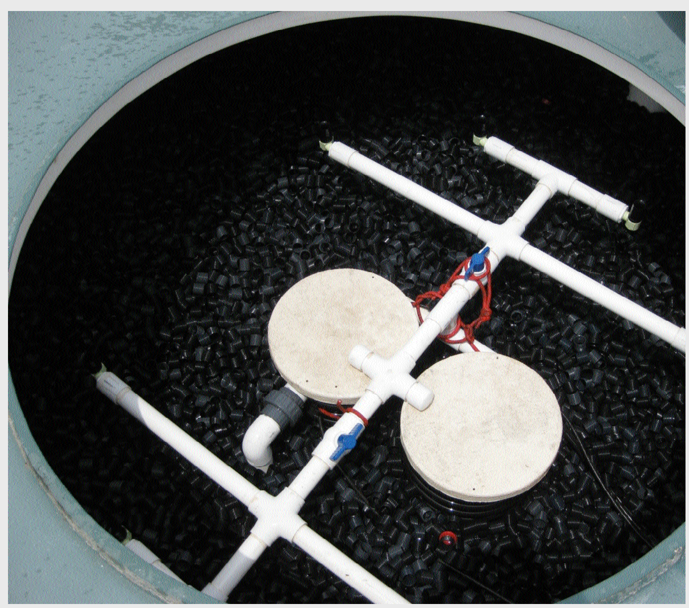
The configuration of a decentralized wastewater system is similar to that for a centralized system—consisting of collection piping and pumps, treatment, and effluent discharge, dispersal, or reuse.

The collection systems associated with decentralized approaches typically are smaller and less expensive on a unit cost basis than those associated with centralized systems. Centralized systems typically rely on large, interconnected collection systems consisting of gravity piping connecting buildings to gravity sewer mains that then connect to lift stations and pressurized forcemains. Because the number of users connected to any given section of pipe may be quite large, the pipes required are also larger and more expensive than those used in decentralized systems. Because these pipes often have to maintain a minimum velocity while conveying water long distances, across roads and creeks, they often need to be buried deeply, which adds significant costs. Collection in decentralized systems can range from a gravity service line connecting a building to a primary treatment unit (e.g., septic tank or grease trap) to small-diameter gravity or pressure sewers (which may be preceded by septic tanks at the buildings), connecting to a larger cluster-type system. Because these pipes carry only primary treated effluent with little or no infiltration, and convey smaller flows to more proximate locations, they can have smaller diameters and be buried relatively shallowly with simple, cost-effective installation procedures. The shallow installation reduces infiltration and avoids pumping water long distances to remote treatment plants, thus minimizing energy costs.

Decentralized system treatment processes have some similarities to those for centralized systems. With decentralized systems, preliminary and primary (settling) treatment typically is provided in a single unit—the septic tank—which may be supplemented with a grease trap for food service or other similar facility types. Secondary—or biological—treatment may be provided using external reactors fitted with suspended growth (e.g., activated sludge); more passive, stable and reliable attached growth (e.g., trickling and other biological filters); and hybrid (e.g., membrane bioreactor) processes for pretreatment before soil infiltration or tertiary treatment. Tertiary treatment for reuse applications or sensitive receiving environments may include disinfection (typically using chlorine or ultraviolet light), advanced mechanical filtration, and other systems as required.

Typically, passive biological treatment using natural processes, such as soil-based filtration or constructed wetlands, are more practical at the smaller scales associated with decentralized management. Dispersal of pretreated effluent into a well-designed and operated soil dispersal field provides an advanced level of secondary treatment. Soil dispersal typically enables enhanced sequestration of phosphorus and, in some cases, denitrification, if not provided in the pretreatment unit.

The DWRC has sponsored several projects on the functions of different unit processes when used in decentralized systems, and the factors influencing their performance. Factors Affecting the Performance of Primary Treatment in Decentralized Wastewater Systems analyzed the literature and other research addressing the performance of septic tanks and grease traps in decentralized



Attached growth pretreatment units like the one pictured above often are used in decentralized systems.

wastewater systems. The report summarizes the state of knowledge on design, construction/installation, and operation, monitoring, and maintenance issues. It focuses on factors most likely to affect primary unit treatment objectives, such as influent characteristics, sizing, hydraulic design, compartmentation, influent and effluent appurtenances, and seasonal effects, among others. Because the effect of water softeners on primary treatment units and soil dispersal systems has been debated, the DWRC sponsored Performance Effects of Water Softener Brine on Onsite Systems: Workshop to bring together stakeholders to define research to evaluate whether there are negative effects to onsite systems from water softener brine, and if so, what can be done to mitigate the problem.

Analysis of Existing Community-Sized Decentralized Wastewater Treatment Systems looked at the performance of a variety of primary, secondary, and tertiary treatment technologies used for community-sized systems. Performance and Costs for Decentralized Unit Processes provides guidance on the performance of decentralized wastewater unit processes and templates for user-directed determination of costs of various systems.

Assessment of Grease Interceptor Performance evaluates field grease interceptors through their separation and cleaning cycles, and used controlled laboratory-scale grease interceptor tests and numerical simulations to assess removal efficiency at different residence times and under different geometric configurations. The FOG (Fats Oils Grease) Interceptor Design and Operations (FOGI-DO) Guidance Manual outlines recommendation for the sizing and configuration of grease interceptors.

Other DWRC projects looked beyond broad performance measures at specific treatment challenges and ways to optimize different unit process technologies. One project analyzed options for a common issue, managing phosphorus in decentralized systems. Micro-Scale Evaluation of Phosphorus Management: Alternative Wastewater Systems Evaluation summarizes application, performance, cost-effectiveness, and other factors associated with a variety of phosphorus-management methods used in decentralized wastewater treatment. WERF and the DWRC also sponsored a series of projects examining the design and performance of constructed wetland treatment systems, including Small-Scale Constructed Wetland Treatment Systems, which provides guidance for designers and operators of small-scale wetland systems, and the DWRC-sponsored student research projects: Development of Design Criteria for Denitrifying Treatment Wetlands; Nitrogen Removal and Sustainability of Vertical Flow Constructed Wetlands for Small-Scale Wastewater Treatment: Recommendations for Improvement, and Improving the Efficacy of Wastewater Polishing Reed Beds.

For stormwater management, DWRC has sponsored research on the design and performance of green roofs and bioretention. Hydrologic Bioretention Performance and Design Criteria for Cold Climates provides practical design, installation, and maintenance recommendations that optimize hydrologic performance of bioretention cells in cold climates. Quantifying Evaporation and Transpirational Water Losses from Green Roofs and Green Roof Media Capacity for Neutralizing Acid Rain evaluated the effectiveness of green roofs for stormwater runoff reduction and the effect of plants on performance and described the buffer potential of green roof media.

■ Does the soil provide any treatment, or is it just for dispersing wastewater effluent? If so, what tools are available to help design soil-based treatment systems and model their performance?

Yes, soil provides treatment. Final effluent disposition in decentralized systems is usually via soil dispersal or a consumptive effluent reuse system. For the vast majority of soil-dispersing decentralized wastewater systems, the soil unit is a critically important treatment unit process, providing a multitude of biological, chemical, and physical functions that improve effluent quality. Most treatment in soils occurs in the biozone. This zone is a biologically active area (often at the interface of the dispersal infrastructure and the natural soil) where pollutants in pretreated effluent are removed by processes that include physical filtration of bacteria and other constituents, adsorption of viruses and bacteria by clay and organic matter, biological destruction of pathogens by soil microorganisms, sorption or precipitation of phosphorus, biochemical transformations of nitrogen compounds, and biological assimilation of phosphorus and nitrogen.

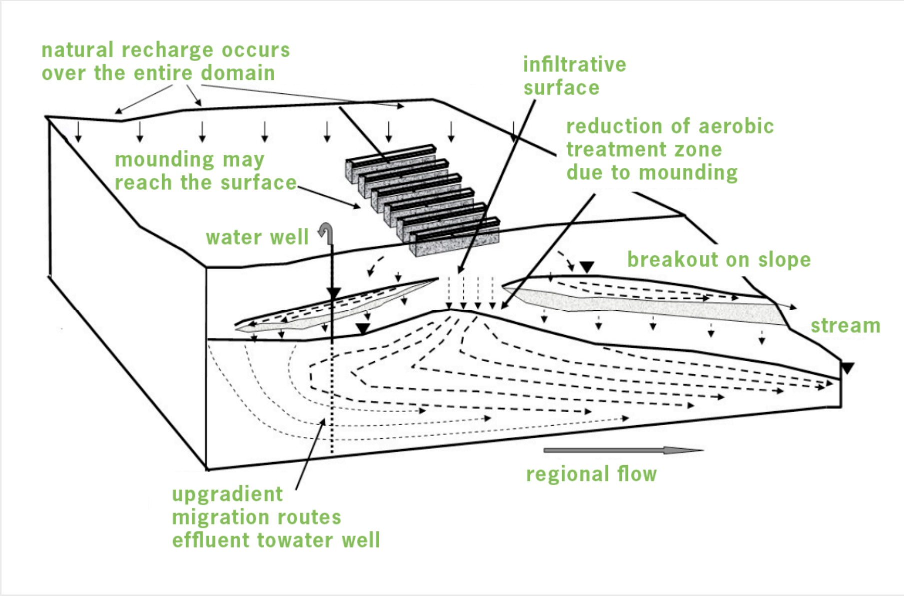
Soil dispersal provides several advantages over systems that discharge effluent directly to surface waters by enabling advanced biological, chemical, and physical treatment of the effluent in the soil before the effluent mixes with or supplements groundwater or downgradient surface water. This slow infiltration of highly treated effluent through subsurface groundwater systems helps restore natural hydrologic function in watersheds by recharging aquifers and maintaining stream baseflows.

Although pretreatment systems for soil dispersing systems typically do not need to meet surface water discharge standards, they do need to provide effluent of sufficient quality for advanced treatment in the soil. Decentralized management differs from centralized wastewater management approaches by using the soil as a treatment unit of its own; performance depends on quality of the water and on other often overlooked factors, such as construction-phase management of receiving soils and the rate of effluent dispersal.

Performance of Engineered Pretreatment Units and Their Effects on Biozone Formation in Soils and System Purification Efficiency provides some guidance on when and how to apply increasing levels of pretreatment to cost-effectively treat wastewater at a given site, based on the biozone formation potential of various quality effluents. Because measuring and predicting treatment within the soil unit can be challenging, Distributed Systems: Determining the Expected Performance of Unit Processes provides a protocol and tools that can be applied by users with varying amounts of technical knowledge to determine the expected performance of the soil treatment unit based on known wastewater characteristics and site conditions. (State of the Science: Review of Quantitative Tools to Determine Wastewater Soil Treatment Unit Performance was a precursor literature review project that supported development of the protocol.)

Except in some cases where effluent has been highly nitrified before dispersal and where labile carbon availability and anoxic conditions may be preferred to enhance denitrification, treatment within the soil unit is often dependent on providing aerobic conditions, which requires an unsaturated zone (the vadose zone) between the point of dispersal and the underlying groundwater table. The application of effluent to a soil dispersal field can, under certain conditions, artificially increase the height of the water table under the application area—an effect known as "groundwater mounding". Predicting the height of the groundwater mound and ensuring that it does not encroach upon the needed unsaturated, aerobic, soil treatment zone is critical for effective soil-based treatment. Guidance for Evaluation of Potential Groundwater Mounding Associated with Cluster and High-Density Wastewater Soil Absorption Systems presents a methodology for evaluating site conditions and system design influences for potential for groundwater mounding and lateral spreading.

It is well-documented that the combination of external pretreatment and soil-based dispersal can treat wastewater to a high standard that is comparable to or, in some cases, better than centralized treatment. The ability to make accurate predictions about the watershed-scale effects of decentralized systems, however, is critical to



The potential for groundwater mounding below wastewater soil-absorption system can be predicted using techniques described in DWRC projects (source: National Decentralized Water Resources Capacity Development Project (2005) *Guidance for Evaluation of Potential Groundwater Mounding Associated with Cluster and High-Density Wastewater Soil Absorption Systems*; National Decentralized Water Resources Capacity Development Project: St. Louis, Missouri.)

support their use as long-term, sustainable components of water resource infrastructure. Accordingly, the DWRC has sponsored several projects on the fate and transport of constituents in decentralized system effluent at the watershed scale.

Modeling Onsite Wastewater Systems at the Watershed Scale: a User's Guide provides guidance for conducting watershed-scale modeling assessments and decision-making associated with onsite wastewater system pollutants, and includes discussion of fundamental modeling concepts, hydrology, and pollutant transport and provides an introduction to various models, including their selection and use. Case studies are included that demonstrate how the methodologies presented in the guide can be applied. The results of this project are particularly useful to engineers who need to implement models for quantitative evaluations of problems at the watershed scale, and to individuals who want to understand how models are used for watershed assessments and decision-making.

Quantifying Site-Scale Process and Watershed-Scale Cumulative Effects of Decentralized Wastewater Treatment Systems developed and tested a methodology for assessing the water quality effects of decentralized systems on local water supply wells and downstream receiving waters. Site-scale processes were incorporated into an existing watershed model used to simulate cumulative effects and water quality responses in a watershed or sub-watershed. The model was then used as a decision-supp o rt system to engage stakeholders in the development of total maximum daily loads (TMDLs) for onsite wastewater system discharges in the Blue River tributary of the Lake Dillon watershed in Colorado.

The presence of potentially disruptive organic compounds (i.e., pharmaceuticals and personal care products) in surface and groundwaters throughout the United States is an urgent emerging issue. Influent Constituent Characteristics of the Modern Waste Stream from Single Sources detected both consumer product chemicals (caffeine, ethylenediaminetetraacetic acid (EDTA), 4-nonylphenolmonoethoxylate (NP1EO) and triclosan) and pharmaceutical residues (ibuprofen, naproxen, and salicylic acid) in raw wastewater and septic tank effluent. Organic Wastewater Compounds, Pharmaceuticals, and Coliphage in Groundwater Receiving Discharges from Onsite Wastewater Treatment Systems Near La Pine, Oregon: Occurrence and Implications for Transport documents the occurrence of organic compounds from personal care products, common household chemicals, phamaceuticals, and coliphage in onsite wastewater systems, and their fate and transport in the groundwater system. Performance Dynamics of Trace Organics in Onsite Treatment Units and Systems is a student research project that compares the effectiveness of several decentralized wastewater t reatment processes on trace organic contaminant removal and on the role of water quality in performance and removal.

DWRC's watershed modeling projects provide information that will help planners and designers assess the fate of potentially disruptive organic compounds in decentralized systems and in watersheds.

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What are the direct monetary costs associated with various types of decentralized systems?

One of the most significant challenges for wastewater and stormwater management is the need to quantify the true costs of centralized and decentralized approaches, from design and construction through operation and maintenance, and ultimately through the inevitable need to replace or refurbish treatment systems. The second half of this challenge is how to help municipalities, water management districts, and others responsible for infrastructure develop realistic, affordable ways to finance water infrastructure.

Because system costs vary depending on type, size, location, configuration, management program, and other factors, Performance and Costs for Decentralized Unit Processes provides tools to estimate the monetary costs associated with a variety of different onsite and cluster-scale decentralized wastewater systems. Analysis of Existing Community-Sized Decentralized Wastewater Treatment Systems also documented the capital and recurring costs of cluster systems.

What are the life-cycle costs of decentralized systems and how do those costs compare to centralized alternatives?

Life-cycle costing analysis considers the full suite of costs (or effects) and values (or benefits) of a system, including both monetary and non-monetary costs:

- Capital and recurring costs associated with development, operation, and upkeep or replacement for extraction, conveyance, and treatment infrastructure;
- Financing (debt service) costs;
- Embedded costs (e.g., life-cycle energy inputs) associated with construction and installation;
- Secondary or implied costs associated with, for example, land use and ecological or hydrologic effects of water infrastructure decisions; and
- Recovered value, such as revenue generated through recovery of energy or nutrients from waste and the drinking water savings realized by reusing effluent; or, in a more extended analysis, the natural services provided by ecosystems whose functions are preserved or enhanced by the infrastructure system (e.g., constructed wetlands, restored streams, etc.).

Decentralized systems often offer advantages over traditional centralized infrastructure projects when life-cycle costing is done. For example, with shorter distances between wastewater generators, treatment systems, and dispersal or reuse areas, pipe runs often are shorter and less expensive and require less energy for conveyance, reducing energy use. Decentralized systems are also well-suited to phased or modular implementation, with smaller capital outlays requiring less, or zero, debt financing. The secondary benefits of decentralized systems include hydrologic preservation or restoration (through soil dispersal) and enhanced ecosystem and landscape values. Resource recovery at decentralized scales is both efficient and practical. (See Integrated Resource Management Study, Qualitative Decentralised System Concepts, Volume 1, and Qualitative Decentralised System Concepts, Volume 2.)

The DWRC has sponsored several projects to help decision-makers evaluate whether and how to make decentralized systems part of their community's water infrastructure. Methods for Comparison of Wastewater Treatment Options evaluates analytical tools and methods that can capture the environmental consequences of alternatives in monetary and non-monetary terms. Methods evaluated include life cycle assessment and associated software, environmental impact assessment, exergy evaluation, and the sustainability process index. Decentralized Wastewater System Reliability Analysis Handbook helps practitioners select asset management tools best suited to manage the reliability and cost of decentralized systems. On an even more practical level, Case Studies of Economic Analysis and Community Decision-Making for Decentralized Wastewater Systems features real-life communities that assessed the benefits and costs of different options (onsite, cluster, and centralized options) using both monetary or non-monetary measures. The report examines the driving issues, motivations, thought processes, and decision-making methods stakeholders used in choosing a system.

What greenhouse gas emissions are associated with decentralized systems?

There are several potential energy-saving aspects of decentralized systems including their proximity to wastewater sources and effluent reuse areas and an enhanced ability to use passive, energy-efficient treatment technologies. Although these efficiency attributes help reduce the overall carbon footprint of decentralized systems, in terms of direct greenhouse gas emissions, methane is the principal compound of concern. Evaluation of the Potential for Methane Greenhouse Gas (GHG) Emissions from Septic Systems evaluates existing and new data on methane emissions from septic systems and studies whether any degradation pathways can be expected to transform methane into other compounds instead of releasing it into the atmosphere. These are the types of data needed to produce accurate GHG inventories so that the effects of septic systems can be characterized at larger scales.

Can state revolving funds and other typical funding sources be used to finance decentralized systems?

Maybe. Although it depends on the state and the state revolving fund (SRF) in question, states increasingly are providing more public financing options for decentralized and other non-conventional approaches. Many DWRC case studies illustrate how communities have used SRF and other funding sources to implement decentralized systems. The Clean Water SRF is designated for new or improved wastewater treatment facilities. Some states have clearly specified that soil-discharging individual and clustered systems qualify for SRF funding; others disqualify any treatment facilities owned by private individuals (i.e., not publicly owned and operated).

Funding for decentralized systems also was prioritized through the Green Project Reserve (GPR) of the American Recovery and Reinvestment Act (ARRA) of 2009. The GPR singled out projects featuring water and energy efficiency, green infrastructure, and environmental innovation for funding priority; eligibility criteria specifically included the use of decentralized stormwater and wastewater infrastructure. Although ARRA 2009 funding is completed, the principles of GPR have been carried forward to 2010 funding and are expected to be a part of future U.S. EPA funding of SRF programs.

A parallel program to the Clean Water SRF, the Drinking Water SRF program, funds activities intended to meet the goals of the federal Safe Drinking Water Act that focus on providing safe, potable water to homes and businesses. These activities can include protecting sources of drinking water, although funding for repair or replacement of onsite systems threatening drinking water sources is rare.

The U.S. EPA has published a fact sheet on using Clean Water SRF funds for decentralized systems and reviewed other funding sources and methods. Additionally, the Coalition for Alternative Wastewater Treatment developed a detailed catalog of federal agency funding programs that may be available for pilot and full-scale decentralized wastewater projects.

ONSITE WASTEWATER PROGRAM FUNDING SOURCES

Local Revenues and Taxes. Many communities fund important community services through local revenues such as property taxes. If only a portion of a community requires management of wastewater systems, tax increment financing may be one way to utilize a portion of the taxes collected from that neighborhood for the purpose of managing their systems.

User Fees. A common way to pay for wastewater treatment and management services is through user fees, as part of a regular sewer bill. In this way, the cost of providing management services is spread out throughout the year. This approach works especially well if another public utility, like a water company or electric company, is providing the wastewater management services.

Permit Fees. Operating permit fees fund most state environmental permitting programs. This concept can be extended to individual and clustered treatment systems.

Payment for Services. Some communities bill property owners when the service is delivered. While this approach may make budgeting and planning more difficult, it works well in communities that have a wide range of service needs.

Decentralized water management programs often use various grants and/or loans, general state/local revenues, property taxes, user fees, permit fees, and direct payment for services to fund operations (Source: U.S. Environmental Protection Agency (2010) *Interactive Handbook for Managing Individual and Clustered (Decentralized) Wastewater Treatment Systems*; U.S. Environmental Protection Agency, Office of Water: Washington, D.C.).

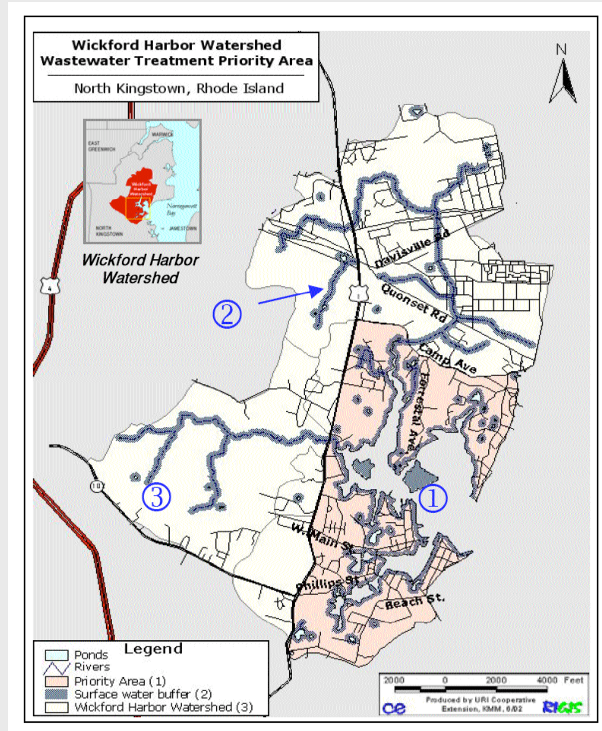
Do decentralized systems have to be professionally managed? Isn't it difficult and expensive to manage so many small systems?

Yes, decentralized systems require management. In fact, the lack of adequate and sustained management is at the root of many shortcomings of traditional septic systems. Because proper and professional management is one of the most important factors to ensure performance and reliability of decentralized systems, there are many examples of cost-effective programs to draw on for experience.

Since the U.S. EPA's management guidelines were issued in 2003, professionally managed decentralized wastewater systems have been implemented in communities throughout the United States and abroad. Both public and private service providers have emerged to fill this need, operating as *responsible management entities* (RMEs) under a variety of nonprofit, governmental, and for-profit structures. Ownership and operation of decentralized systems by RMEs has become commonplace and been shown to be a successful management model.

Successful RMEs combine tracking and data management tools with physical inspections of onsite systems and the use of remote monitoring systems or "telemetry". Non-traditional Indicators of System Performance describes existing technologies that can be used to get relevant real-time information about water quality at a treatment system's point of compliance (i.e., end-of-treatment unit or receiving-water outfall). Wastewater Planning Handbook: Mapping Onsite Treatment Needs, Pollution Risks, and Management Options Using GIS is a guidance manual for small communities about using computer-generated maps and databases for water management planning with a focus on relatively low-cost, screening-level analysis and available databases to target high-risk pollution sources.

A responsible management entity is defined as a legal entity that has the managerial, financial, and technical capacity to ensure long-term, cost-effective operation of onsite and/or cluster wastewater treatment systems in accordance with applicable regulations and performance requirements (e.g., a wastewater utility or wastewater management district).



Geographic information systems mapping and other computer-generated maps and databases can assist in assessing decentralized management needs as a part of comprehensive watershed planning (Source: National Decentralized Water Resources Capacity Development Project (2004) Cluster Wastewater Systems Planning Handbook; National Decentralized Water Resources Capacity Development Project: St. Louis, Missouri.)

Remote monitoring via telemetry and spatial information and data management systems increasingly is being used to facilitate management of multiple, dispersed systems. Advances in technology and more widespread implementation of these "smart IT systems" are envisioned to be the building blocks of a future infrastructure architecture where networks of decentralized systems will be fully integrated into centralized management programs.

How can my community establish a responsible management entity (RME)? What are some examples of successful RMEs?

Responsible management entities can provide the administrative framework to ensure that decentralized wastewater treatment systems protect both public health and the environment over the long term. Guidance for Establishing Successful Responsible Management Entities provides detailed guidance on establishing and running RMEs. It includes series of fact sheets with detailed steps for communities looking at decentralized management; prospective RMEs looking at becoming involved in management; and existing RMEs seeking to improve their operations.

Business Attributes of Successful Responsible Management Entities analyzed successfully operating RMEs and describes characteristics of both their formation and business operation. Using the experiences of successful RMEs, this study outlines strategies for forming management programs in specific situations, such as regions that rely principally on existing decentralized systems; regions where decentralized treatment is being used in infill and redevelopment; and areas undergoing new growth and development using new decentralized systems.

Is training required for operators and installers of decentralized wastewater systems?

Yes. Training requirements for decentralized system operators and installers are determined by the licensing requirements of the applicable state. Many states require operators and system installers to take classes and pass an exam before licensing, and most state licensing programs require continuing education to maintain licenses.

The DWRC has sponsored several projects that enhance and improve operator and installer training within the decentralized field. The Installer Training Program project provides pilot training events and presentations to be used and delivered by a coalition of organizations. The Decentralized Wastewater Treatment O&M Service Provider Training Program provides training on the operation and maintenance of onsite treatment systems. These training materials focus on the operation of single-family residential systems and provide a consistent and updated knowledge base for service providers in this growing industry. Additional training resources can be found on the website for DWRC partner, Consortium of Institutes for Decentralized Wastewater Treatment.

What are the operation and maintenance demands and costs of various types of decentralized wastewater systems? How are unexpected, high-cost repairs paid for in a management program?

As with any wastewater treatment and collection system, the key to long-term performance is understanding, planning for, and funding proper operation and maintenance, including a capital repair and replacement fund. Although there are some differences and nuances to managing distributed and decentralized systems, the basic principles are the same as for centralized systems.

All properly managed RMEs will have a capital repair and replacement fund, which allocates a portion of user fees for major repairs or future system replacement. An RME with the ability or authority to charge user fees from its customer base would, as in a central sewer or water authority, allocate appropriate portions of fees to operation and maintenance and to a capital or sinking fund.

The particular operation and maintenance demands of decentralized systems will vary according to the type, size, and complexity of the systems being managed, and the potential for replacement costs. The sensitivity of the receiving environment or the potential for risks to human health also can influence the level of oversight necessary for a system. One advantage of decentralized systems is the ability to invest incrementally in smaller treatment units, which can reduce or avoid significant financial and debt service costs associated with refurbishing or expanding a conventional WWTP. The costs associated with decentralized operation and maintenance have been addressed in several DWRC-sponsored projects, including Performance and Costs for Decentralized Unit Processes and Analysis of Existing Community-Sized Decentralized Wastewater Treatment Systems. The latter

The Decentralized Wastewater Treatment O&M Service Provider Training Program provides training on the operation and maintenance of onsite treatment systems focusing on the operation of single-family residential systems.

project analyzed data on the performance of large-scale decentralized and small-community systems with flows ranging from 20 to 200 m^3/d (5 000 to 50 000 gpd) with at least five years of operating history.

The types of operation and maintenance programs evaluated in these reports reflects the diversity of decentralized management programs available. Any program must be tailored by the RME to consider the types of systems and treatment processes being used. The specific tasks of the RME will differ from a centralized system and can include tasks similar to those associated with operation and maintenance of a stormwater utility's treatment systems or best management practices.

Most decentralized wastewater systems have some kind of primary treatment unit (septic tank or grease trap) that periodically needs to be pumped of accumulated materials; effluent screens, if any, also must be washed. (Required frequency for pumping primary treatment units depends on their size relative to the influent flow rate and factors specific to the buildings being served.) Many decentralized systems include an external secondary, or biological, treatment unit. These units typically require more intensive monitoring and maintenance than do completely passive septic systems, but the attached growth systems—like sand, textile, or plastic media filters—are robust. These will require periodic inspection and maintenance of the filter medium, checking and as-needed repair of pumps, and cleaning of dispersal devices such as spray nozzles or drip emitters. The suspended growth (or activated sludge) processes typically used for centralized systems, and found in some decentralized programs, require more frequent monitoring and removal of settled sludge and other routine maintenance.

Soil dispersal areas typically require little maintenance; however, routine inspection is critical to identify potential problems before loss of function. Pressurized dispersal devices such as spray nozzles or drip systems must be flushed periodically of accumulated solids so that they continue to disperse effluent evenly across the soil area. Using multiple soil application areas, where one or more can be rested for weeks or months at a time, has been shown to be a good design feature for system longevity.

■ How many years can a decentralized system be expected to last before needing to be replaced?

Like centralized systems, decentralized systems often have a planned design life of 20 to 30 years; however, many conventional septic systems have been in operation for 50 years or more without obvious problems. In cases of poor designs, a lack of understanding of soil characteristics, or improper operation and maintenance, however, systems may fail in advance of their design life. Improving performance through proper design, installation, and maintenance helps ensure that wastewater treatment resources are well spent.

Asset management has become a common framework for the financial and capital management of centralized wastewater systems, and it has is now becoming common for professionally managed systems in the decentralized field. Decentralized Wastewater System Reliability Analysis Handbook produced a framework for selecting appropriate asset management and reliability assessment tools for RMEs, and provides information about the reliability of decentralized treatment systems and their components. The handbook helps managers estimate the performance of decentralized wastewater systems and enables managers to relate performance to different engineering, ecological, public health, and socioeconomic goals.

How are decentralized wastewater systems regulated, and how does that affect their potential for use as water resource infrastructure?

One of the key issues for scaling up decentralized systems as an alternative or complement to conventional centralized systems, is the often fragmented nature of system regulation and oversight at state and local levels. Individual onsite treatment systems discharging to soil typically are regulated by state or local departments of health; larger systems are primarily regulated by state environmental agencies, such as a groundwater, water resource, or natural resource department. One of the primary reasons for this fragmentation is that systems serving more than one building are defined as "large capacity septic systems" under the federal Safe Drinking Water Act, which classifies them as Class V underground injection control wells.

Several DWRC projects address these fragmented regulations and how they affect decentralized management. The project Analysis of Existing Community-Sized Decentralized Wastewater Treatment Systems evaluated the regulatory landscape for small community and cluster systems in 13 states, and Cluster Wastewater Systems Planning Handbook includes additional information about regulations affecting the implementation of cluster systems. A compilation of the states' decentralized wastewater regulations is maintained by the Small Flows Clearinghouse of the National Environmental Services Center at West Virginia University.

Regulatory programs for individual onsite wastewater systems typically are prescriptive in nature and focus on installation of a limited and defined group of system types at locations that meet a set of defined site criteria, such as allowable soil types, maximum slopes, minimum depths to groundwater, and setbacks from surface waters, structures, and property lines (see Chapter 6 in http://www.epa.gov/owm/septic/pubs/urban_guidance.pdf). Oversight agencies ensure that site conditions meet these minimum criteria but may allow some adjustment or variance in the systems' location, configuration, size, and type. Although inspections during construction are common, further inspections to monitor system performance are not and are required in only a few jurisdictions (see http://www.epa.gov/owm/septic/pubs/dwm_5.pdf). Inspection requirements typically are more stringent for advanced onsite treatment systems than conventional septic systems.

A cluster system being installed in a residential neighborhood (photo courtesy of Infiltrator Systems Inc.).

For clustered and other large-capacity decentralized wastewater systems, regulatory oversight tends to be more stringent. State water resource agencies often will specify design requirements based on flow, strength, and site conditions and may require long-term operation and maintenance performed by a certified professional service provider or RME (see Chapter 5 of http://www.epa.gov/owm/septic/pubs/onsite_handbook.pdf). These systems typically must be designed by a licensed professional engineer.

■ What regulatory approaches support sound management and use of decentralized systems? What are good examples of these?

Several DWRC projects, including Business Attributes of Successful Responsible Management Entities and Case Studies of Economic Analysis and Community Decision-Making for Decentralized Wastewater Systems, provide excellent case studies that illustrate examples of regulations that support sustainable decentralized system management. Regulatory barriers (and potential solutions) to the equitable use of decentralized approaches are covered in Sustainable Water Resource Management, New Approaches in Decentralized Water Infrastructure, and Overcoming Barriers to Evaluation and Use of

Decentralized Wastewater Technologies and Management. Integrated Risk Assessment for Individual Onsite Wastewater Systems developed an approach to risk-based decision-making for individual onsite treatment systems that may be of use to regulators, permitting entities, and system designers.

Regulatory approaches that integrate wastewater, stormwater, and water resource management with planning, zoning, and development functions typically provide the most effective and efficient results for meeting environmental and community goals (see http://www.epa.gov/owm/septic/pubs/dwm_2.pdf). It is best when these management approaches include system performance standards, rather than the strictly prescriptive codes that typically govern onsite systems. Designers are able to address specific factors important to the community or the watershed (see http://www.epa.gov/owm/septic/pubs/dwm_3.pdf and http://www.epa.gov/owm/septic/pubs/dwm_7.pdf).

Two case studies highlighted in DWRC projects provide examples of effective regulatory strategies that bridge the gap between individual on-site systems and central or cluster systems. The Village of Warren, Vermont, solved its wastewater issues with a combination of onsite and larger cluster systems and a decentralized management program that was integrated with local zoning. A wastewater committee and town elected officials worked together to develop solutions, along with complimentary zoning and plans, that protected the historic character, land-use pattern, and densities in the historic village. The plan maximized use of well-functioning septic systems to limit the size of the central cluster system, reserving capacity for properties with no onsite alternative and alleviating concerns that new growth would be promoted to fund the main cluster system. (For more information, see http://asae.frymulti.com/abstract.asp?aid=6082&t=2.)

The town of New Shoreham, Rhode Island, adopted a watershed approach to address the community's dual objectives of managing growth and protecting its drinking water aquifer. The town's comprehensive and sewer facilities plans restrict centralized sewer service to the harbor business and village district to limit sprawl and excessive water use (see https://www.forester.net/ow_0609_wastewater.html).

These are just a few examples of best practices in decentralized wastewater treatment; more are cited in Case Studies: Building Blocks for Decentralized Wastewater, which documents efforts by researchers, private companies, advocates, and state regulatory agencies developing innovative ways to advance the decentralized approach in the United States. Update of the Advanced On-Site Wastewater Treatment and Management Market Study provides the status of regulations, management, technology use, funding, training programs, and research and demonstration projects in each of the fifty states.

At the federal level, Federal Policies to Advance Decentralized and Integrated Water Resource Infrastructure from The Coalition for Alternative Wastewater Treatment suggests that lack of coordination among agencies have led to federally mandated and funded projects that have overstressed the environment and wasted resources. The report stresses the need for integration across water and other infrastructure programs. Some federal actions that would improve water management in the United States include removing the strong bias in federal funding and regulations favoring centralized solutions, integrating and coordinating the missions of federal agencies involved with water supply and quality, and ramping up and revitalizing basic research and demonstration programs. New Approaches in Decentralized Water Infrastructure also includes a report on federal financing directions.

■ Are there additional regulatory concerns related to the use of decentralized systems serving industrial, institutional, or commercial wastewater sources?

Yes. Although decentralized systems have been designed and operated successfully across a range of industrial and institutional sites, additional treatment and design considerations and appropriate management are required to ensure sound operation and environmental outcomes. Depending on the nature of the activities in an industrial, institutional, or commercial facility, these wastewater systems may require additional pretreatment processes (i.e., for removal of specific constituents from the wastewater) before discharging to a soil treatment system. For example, an industrial operation that uses a large amount of organic solvents might be required to

Large subsurface dispersal systems may be regulated as Class V wells under the Safe Drinking Water Act's Underground Injection Control Program. (Source: Premier Tech Aqua)

capture, clean, and reuse solvents, rather than flush them down the drain to prevent upset to the biological processes in the treatment system and possible groundwater contamination.

The U.S. EPA and the states typically have more stringent regulations for soil-discharging wastewater systems that handle nonresidential wastes, such as industrial and some commercial facilities. Large capacity septic systems (LCCSs) are defined as those soil-based systems that receive solely sanitary waste either from multiple residential dwellings or from a nonresidential establishment having the capacity to serve 20 or more persons per day. In addition to the typical underground septic tank and gravity-fed effluent soil distribution system, LCSSs also may have grease traps along with other features, such as additional pretreatment technologies, multiple small septic tanks, or connections to one, large soil-absorption system or multiple absorption areas that can be used on a rotating basis.

The disposal of industrial waste into soil-discharging treatment systems can inhibit soil-based wastewater treatment and cause these systems to malfunction. More importantly, toxic chemicals can pass through these systems untreated, enter the ground water, and pose serious public health threats. To safeguard against this type of contamination, the Safe Drinking Water Act (SDWA) requires that U.S. EPA set minimum federal requirements to prevent the endangerment of underground sources of drinking water. A septic system that receives wastes other than sanitary waste is known as an *industrial waste disposal well*. A septic system that receives vehicular repair or maintenance waste is known as a *motor vehicle waste disposal well*. A covered pit that receives sanitary waste from multiple dwellings or a nonresidential location and has the capacity to serve 20 or more persons per day is known as a *large-capacity cesspool*. As of 2000, new motor vehicles waste disposal wells and large-capacity cesspools are banned. For more information on how soil-discharging industrial treatment systems are regulated, see http://www.epa.gov/safewater/uic/class5/pdf/study_uic-class5_classvstudy_fs_industrial.pdf.

■ Are decentralized systems that use soil-based dispersal or reuse subject to Underground Injection Control regulation as Class V injection wells?

Yes, soil-discharging systems that receive wastewater either from multiple dwellings or a nonresidential establishment that has the capacity to serve 20 or more persons per day are defined as large capacity septic systems (LCSSs) and are considered Class V wells that are subject to regulations under the Safe Drinking Water Act's Underground Injection Control Program. Systems that receive wastes other than sanitary waste are considered to be industrial wells (see above). Systems that serve fewer than 20 persons and receive solely sanitary wastes are not Class V wells (see http://www.epa.gov/safewater/uic/class5/types_lg_capacity_septic.html).

Most LCSSs are regulated on a "permit by rule" basis—states and U.S. EPA require that they be registered and managed in a way that does not threaten underground sources of drinking water. In some cases, states have established effluent limits for LCSSs to protect drinking water wells (e.g., 10 mg/L for nitrate-nitrogen). Detailed information—and state contacts for regulatory matters—is posted at http://www.epa.gov/safewater/uic/class5/comply_minrequirements.html.

Where can I find more information on decentralized systems?

The U.S. EPA and partner organizations have entered into a memorandum of understanding (MOU) to address the environmental challenges facing the United States in implementing decentralized systems. The agreement formalizes the collaboration between U.S. EPA and its partners to support state and local governments and improve communication about decentralized programs. It focuses on the strategies needed among the partnering associations to implement effective communication to the public about the planning, design, and long-term operation and maintenance of decentralized systems. In addition to the DWRC website, the websites of the MOU member organizations listed below include a wide variety of information about decentralized systems:

- United States Environmental Protection Agency (U.S. EPA)
- National Onsite Wastewater Recycling Association, Inc. (NOWRA)
- National Environmental Services Center (NESC)
- National Environmental Health Association (NEHA)
- Rural Community Assistance Partnership (RCAP)
- National Association of Towns and Townships (NATaT)
- National Association of Wastewater Transporters (NAWT)
- The Water Environmental Federation (WEF)
- Consortium of Institutes for Decentralized Wastewater Treatment (CIDWT)
- Association of State and Interstate Water Pollution Control Administrators (ASIWPCA)
- The Ground Water Protection Council (GWPC)
- State Onsite Regulators Alliance (SORA)
- Water Environment Research Foundation (WERF)
- Association of State Drinking Water Administrators (ASDWA)
- Coalition for Alternative Wastewater Treatment (CAWT)

Local health departments, state environmental agencies, and state cooperative extension service agencies also are excellent sources of localized information on decentralized systems.

How can I access scientific journal articles on decentralized systems?

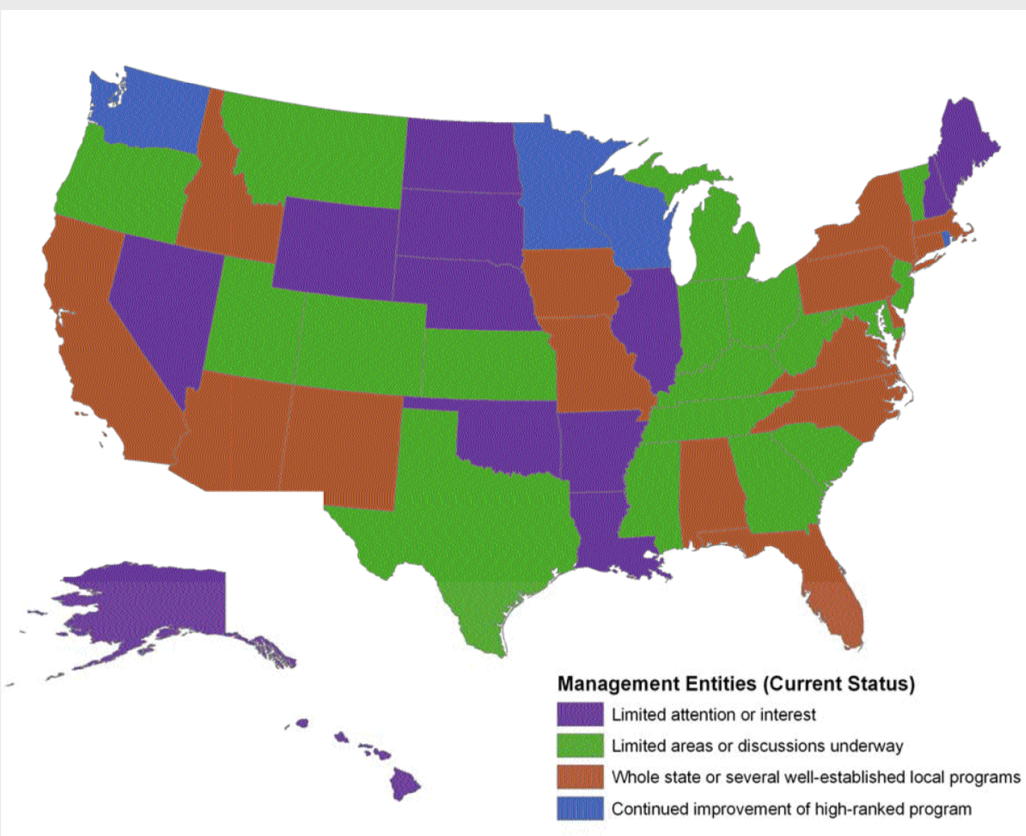
University libraries are good places to conduct searches for journal articles on issues related to decentralized management. Some common search engines that are

New suburbs are using cluster systems to meet wastewater needs while encouraging compact land use development and preserving open space.

used include Argicola, Agris, Compendex, Google Scholar, Scirus, SpringerLink, and Web of Science. The journals and proceedings listed below are some of the most directly related to the field of decentralized management:

- National Small Flows (NSF) Home Sewage Disposal Symposium Proceedings (1974-1981)
- National American Society of Agricultural Engineers (ASAE) Symposium on Individual and Small Community Sewage Systems (1974-2007)
- National Onsite Wastewater Recycling Association (NOWRA) Annual Conference Proceedings
- Water Environment Federation Technical Exposition & Conference (WEFTEC) Proceedings
- Water Environment Federation Specialty Conference Proceedings
- Northwest Wastewater Treatment Short Course and Exposition Proceedings
- ASTM International Site Characterization and Design of On-Site Septic Systems Proceedings
- Water Science and Technology (IWA Publishing)
- Environmental Technology and Chemistry (ACS Publications)
- Onsite Water Treatment (Forester Media)
- Water Environment and Technology (Water Environment Federation)
- Water Environment Research annual literature review issue (Water Environment Federation)

The National Small Flows Clearinghouse maintains a bibliographic database of articles pertaining to decentralized wastewater issues. Additionally, many of the DWRC projects include extensive literature reviews that are excellent places to begin to find out more about a given subject. For example, State of the Science: Review of Quantitative Tools to Determine Wastewater Soil Treatment Unit Performance provides a detailed literature review on modeling tools that can be used to predict site-specific soil treatment performance. Several projects, including Factors Affecting the Performance of Primary Treatment in Decentralized Wastewater Systems, have developed bibliographic databases to facilitate searches.



Current Status of Interest in and Implementation of Management Entities. (Source: Water Environment Research Foundation (2009) *Update of the Advanced On-Site Wastewater Treatment and Management Market Study: State Reports Summary*; Water Environment Research Foundation: Alexandria, Virginia.)

Is there a national database of decentralized systems in use? Are there demonstration sites or case studies that explain more about decentralized and distributed systems in practice?

There is no single source for finding all—or even most—of the decentralized wastewater systems in the United States. Many states, however, have at least a portion (which may be limited to newer systems or large systems) of their decentralized systems identified, often spatially through a geographic information system platform.

Several databases of case studies do exist however. For example, U.S. EPA has sponsored several demonstration projects. Additionally, When to Consider Distributed Systems in an Urban and Suburban Context produced a database of case studies where distributed and decentralized approaches are being used in areas that might traditionally use centralized sewerage. Additional examples are cited in Case Studies: Building Blocks for Decentralized Wastewater, which documents innovative ways that decentralized approaches are being implemented across the United States and is one of several reports from the project, Advanced On-Site Wastewater Treatment and Management Market Study. Collectively, these reports provide updated decentralized market information regarding the status of regulations, management, technology use, funding, training programs, and research and demonstration projects in each of the 50 states. A state-by-state literature review was conducted and individual state reports are provided.

Where can I find resources available to help support public education and training efforts?

A significant amount of work has been done to better educate both college students and the public on decentralized issues. An excellent resource, especially for educators, is the Consortium of Institutes for Decentralized Wastewater Treatment (CIDWT), which provides access to several DWRC-sponsored training resources for various audiences and various topics. These include: National Installer Training Program, Analyzing Wastewater Treatment Systems for High Strength and Hydraulic Loading, National O&M Service Provider Program, Model Decentralized Wastewater Practitioner Curriculum, University Education Curriculum, and Decentralized Wastewater Glossary and Train the Trainer Program.

In addition to sponsoring training and education, DWRC sponsored the development of student researchers in the decentralized field through an unsolicited research program as well as the project, Student Design Competition for Decentralized Wastewater Treatment, including providing seed money to begin a student design competition for decentralized systems.

For stormwater, Decentralized Stormwater Techniques: Training and Dissemination updates WERF's Livable Communities website with new information and tools on planning approaches, economics, technologies, and other areas.

- *For all products from the DWRC, visit www.decentralizedwater.org.*
- *For a video and quick guide of the products mentioned in this FAQs guide, go to www.werf.org/decentralizedoutreach.*