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OVERCOMING BARRIERS TO EVALUATION AND USE OF DECENTRALIZED WASTEWATER TECHNOLOGIES AND MANAGEMENT

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ABSTRACT AND BENEFITS

Abstract:

While the United States Environmental Protection Agency has determined that "[a]dequately managed decentralized wastewater treatment systems are a cost-effective and long-term option for meeting public health and water quality goals" (U.S. EPA 1997), many barriers to decentralized wastewater treatment have been identified, from a patchwork of regulations to inequitable access to public financing.

In this report, the researchers identify the most important barriers to engineers equitably considering decentralized wastewater treatment options, determine the level of influence engineers have in overcoming the barrier(s), and develop strategies and actions. The most influential barriers were classified into four categories:

- Engineers' financial reward for using centralized systems
- Engineers' lack of knowledge of decentralized systems
- Unfavorability of the regulatory system for decentralized systems
- Lack of systems thinking applied to wastewater issues

The project team crafted a list of strategies and actions for overcoming the barriers, based on information from interviews, the literature reviewed, input during conference presentations about the project, and their own experience. For each action, organizations or types of engineers were identified who could carry it out. A communications plan listing means of disseminating the information is included.

Benefits:

- Summarizes the existing barriers to wider adoption of decentralized solutions and provides ways to overcome them.
- Evaluates cases where engineers have already realized success from implementing decentralized wastewater treatment systems.
- Provides understanding of how to ensure that all effective wastewater treatment alternatives are given a fair evaluation on overall environmental and cost effectiveness.

Keywords: Onsite wastewater treatment, cluster system, engineer, distributed infrastructure, technology transfer.

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ABET	Accreditation Board for Engineering and Technology
ACCD	Vermont Agency of Commerce and Community Development
ASABE	American Society of Agricultural and Biological Engineers
AWM	Applied Water Management
BSE	Biological Systems Engineering
CDBG	Community Development Block Grant
CEE	Civil and Environmental Engineering
CEU	Continuing education credit
COG	Council of government
CSMP	Community Septic Management Program
CVCLT	Central Vermont Community Land Trust
DB	Design-build
DBB	Design-bid-build
DBO	Design-build-operate
DBOO	Design-build-own-operate
FE	Fundamentals of Engineering
HUD	United States Department of Housing and Urban Development
ICMA	International City/County Management Association
IRP	Integrated resource planning
ISTS	Individual sewage treatment system
LEED	Leadership in Energy and Environmental Design
LID	Low Impact Development
LCC	Lifecycle costing
MS4	Municipal Separate Storm Sewer Systems
NAWE	North American Wetlands Engineering
NAWT	National Association of Wastewater Transporters
NCEES	National Council of Examiners for Engineering and Surveying
NDWRCDP	National Decentralized Water Resources Capacity Development Project
NEHA	National Environmental Health Association
NEPA	National Environmental Policy Act
NOWRA	National Onsite Wastewater Recycling Association

NPCA	National Precast Concrete Association
NPDES	Nonpoint Source Discharge Elimination System
NSPE	National Society of Professional Engineers
P.E.	Professional Engineer
PE	Principles and Practice of Engineering
PER	Preliminary Engineering Report
PSC	Project subcommittee
RCAC	Rural Community Assistance Corporation
RCAP	Rural Community Assistance Partnership
RFP	Request for Proposals
RME	Responsible Management Entity
RUS	Rural Utilities Service
SD	sustainable development
SORA	State Onsite Regulators Association
SRF	State Revolving Fund
SSC	Stakeholder Sounding Committee
SSWMP	Small-Scale Waste Management Program
SWCD	Soil and Water Conservation District
SWQP	Strategic water quality plan
TMDL	Total maximum daily load
U.S.	United States
U.S. EPA	United States Environmental Protection Agency
USDA	United States Department of Agriculture
UVM	University of Vermont
UW	University of Wisconsin
WEF	Water Environment Federation
WEFTEC	Water Environment Federation Technical Exhibition and Conference
WERF	Water Environment Research Foundation
YOWA	Yankee Onsite Wastewater Association

EXECUTIVE SUMMARY

About 25% of households in the United States are served by decentralized wastewater treatment. Often referred to as onsite systems or septic systems, the term ‘decentralized systems’ also includes shared or cluster wastewater systems, and can even include centralized sewers that are operated together with other systems by a common manager. The United States Environmental Protection Agency (U.S. EPA) has determined that “[a]dequately managed decentralized wastewater treatment systems are a cost-effective and long-term option for meeting public health and water quality goals” (U.S. EPA, 1997). Nonetheless, many barriers to using soundly managed decentralized systems to provide wastewater treatment where appropriate have been identified, from a patchwork of inconsistent regulations to inequitable access to public financing. In many cases, social, environmental, and economic harm results when the most appropriate wastewater treatment solution is not applied.

This study identifies important factors that affect whether engineers equitably consider decentralized wastewater treatment options. The barriers are prioritized to determine which ones were the most influential and solvable, and then strategies and actions are identified through which engineers in different areas of environmental and wastewater-related fields can solve the most influential barriers.

The report focuses predominantly on engineers and what they can do to create an environment where all wastewater treatment solutions are considered equitably and where fair decisions are made for clients and communities. In this evaluation, engineers were considered working in a variety of roles including as private consulting engineers, as university professors and researchers, as regulatory engineers, as municipal or utility engineers, as manufacturers’ engineers, and as members of engineering societies and organizations.

Barriers

Five main types of barriers were characterized:

- Engineers’ **financial reward for using centralized systems**
- Engineers’ **lack of knowledge** of decentralized systems
- Engineers’ **unfavorable perception** of decentralized systems
- **Unfavorability of the regulatory system** for decentralized systems
- **Lack of systems thinking** applied to wastewater issues

The four most influential barriers and most solvable problems identified at the end of the project’s first phase. The barrier category “Engineers’ unfavorable perception of decentralized systems” was dropped from further consideration, as it was determined that this group of barriers could be overcome by focusing on the other four groups. In the second project phase, solutions within each barrier category were proposed and evaluated by the project team and others. The solutions were evaluated both on the basis of their potential effectiveness and on the extent to which the solutions lay within the purview of engineers.

The following barriers were both identified by the research and addressed by recommendations:

Engineers' financial reward for using centralized systems

The logic of this category of barriers is economic and simple: the greater the financial reward for engineers in using, or specifying, centralized wastewater systems, the lower the probability that engineers will equitably consider using decentralized systems in the facility planning process. As many of the barriers identified in this category show, it is often believed to be the case that engineering and specification of decentralized systems provides little financial reward for engineers compared to the use of centralized wastewater systems.

The research identified a large number of barriers in this category. As a result, these barriers were sorted into subcategories. The most influential and solvable barriers were found in two subcategories:

- Demand issues. Barriers in this subcategory result in low willingness of engineers' clients—the entities for which consulting engineers work, or the decision makers that engineers in utilities or government agencies serve—to invest in consideration of decentralized systems.
- Funding availability and conditions. This subcategory includes barriers that result in engineers or their clients believing that decentralized options are less likely to receive financial assistance than centralized options, and therefore are less likely to be implemented.

Engineers' lack of knowledge of decentralized systems

The lack of knowledge of decentralized technology and management among engineers is a major barrier to the equitable consideration of decentralized systems. This lack of knowledge is pervasive in the engineering community, among design engineers, regulators, utility engineers, developer's engineers, and funding agency engineers. The barriers addressed in this category include:

- Universities have limited or no curricula on decentralized technology and management.
- Documented knowledge of decentralized systems and their performance is not widely available to engineers.
- Research funding for decentralized systems is scarce, which reduces the amount and quality of university teaching about decentralized systems.

Unfavorability of the regulatory system for decentralized systems

Regulations and regulators are often unfavorable to decentralized systems, regardless of the applicability of the systems to solving problems. The barriers addressed within this category are:

- Regulators' perceptions and limited knowledge restrict equitable consideration of decentralized systems.
- Regulators need to better define what constitutes "system failure" and "adequate performance" to make use of decentralized approaches more feasible.
- Regulations and codes are often based more on regulating growth than on making good wastewater engineering choices.
- A weak regulatory environment can result in inadequate or failure-prone decentralized systems, which further reduces the likelihood of their use.

Lack of systems thinking applied to wastewater issues

Systems thinking refers to defining the boundaries of a system to adequately encompass significant cause and effect relationships, and understanding the connections between the resources and activities within that system. Advantages of decentralized wastewater options are often only apparent when systems beyond wastewater treatment are considered: On-site reuse in irrigation, for example, can provide a partially drought-resistant source of landscaping water. The recommendations address the following barriers related to the lack of systems thinking in the wastewater facility planning process:

- Systems thinking is not part of the standard engineering curriculum or the typical engineering culture.
- There is a lack of coordination between local government entities responsible for general or land use planning and those responsible for wastewater infrastructure planning.
- Wastewater system planning and water resources planning are usually not integrated at an institutional or regulatory level in the facilities planning process.
- The tendency of decision-makers to focus on immediate costs rather than lifecycle costs hampers consideration of decentralized systems.
- A lack of robust alternatives analysis leads to less holistic solutions.

Recommendations

The project team crafted a long list of strategies and actions for overcoming the barriers, based on information from interviews, the literature reviewed, input at conference presentations about the project, and their own experience. Feedback from WERF's Project Subcommittee and a Stakeholder Sounding Committee was used to focus the strategies and actions to be included in this final report. The team conducted further interviews and other research to more fully describe the strategies, actions, and parties necessary to make the actions happen. Finally, each strategy was further scrutinized to consider financial ramifications, unintended consequences, regulatory impacts, and other implications that might indicate that overcoming one barrier could erect another.

The recommendations emerging from this project are:

Increasing engineers' financial reward for using centralized systems

- Increase availability of financial assistance for decentralized systems by removing biases in funding programs towards centralized systems, creating loan funds targeting decentralized systems, and establishing tax or other credits for upgrading onsite systems.
- Require consideration of decentralized options in regulatory and funding processes, particularly in engineering facility plans.
- Increase public awareness and address misperceptions around decentralized systems, in part through educating local government officials on the financial advantages of decentralized systems.
- Adopt new business models to support engineering firms in using decentralized systems successfully. The business models include new marketing strategies and new ways to compensate engineers for recommending and developing decentralized systems.

Increasing Engineers' Knowledge of Decentralized Systems

- Increase teaching of decentralized systems and technologies with important benchmarks such as: Universities reaching undergraduate engineering students with a minimum of two classroom hours in soil-based treatment and decentralized technologies; universities or other organizations teaching continuing education courses in decentralized to practicing engineers; and increasing funding for decentralized research at universities.
- Develop decentralized questions for the professional engineers' exam.
- Increase data on decentralized technologies, through a management entity applying reliability and costing tools to decentralized systems in an asset management framework.

Increasing the Favorability of the Regulatory Climate for Decentralized Systems

- Achieve greater uniformity in decentralized system regulations. Model regulations help increase the uniformity of regulations themselves, and using a newly developed decentralized wastewater glossary can help standardize the language used in the regulations.
- Broaden support for science-based regulation of decentralized treatment by engaging environmental groups and planners.
- Improve treatment system information management (tracking permits, maintenance, inspections, and monitoring). Regulators can promote high-quality permit, maintenance, and monitoring software. Regulators can also evaluate simplified tracking databases and publicize them if they are helpful. Manufacturers' engineers track operation and maintenance of their own systems.

Increasing Systems Thinking

- Require wastewater planning to include relationships to other wastewater sectors. Develop guidelines for linking wastewater to other sectors.
- Encourage integrated water resources approaches through utilities, by offering developers incentives for water reuse and by encouraging LEED certification for new construction and renovation.
- Train engineers in broad systems thinking. Universities can reach undergraduate engineers through re-designing courses, curricula, and extra-curricular activities. Universities and/or engineering societies can also offer continuing education courses in broad systems thinking to practicing engineers.

Some of these recommendations can be implemented by engineers practicing their profession (design and design review), and some require changes in education, regulations, funding, and other areas. In all of these areas, people trained as engineers occupy positions of influence and can directly or indirectly provide the leadership necessary to make the changes recommended here.

CHAPTER 1.0

INTRODUCTION AND MOST SIGNIFICANT BARRIERS

The wastewater engineering community in the United States has focused primarily on centralized treatment systems or "sewer systems" since the Clean Water Act was passed in 1972, and substantial federal support was directed towards centralized system construction (Copeland, 1999). Both the U.S. Environmental Protection Agency (U.S. EPA) and environmental organizations attribute significant improvements to water quality in lakes and streams to the construction and operation of centralized wastewater treatment plants (Stoner, 2002; U.S. EPA, 2000).

However, the fiscal resources needed solely for funding the present centralized treatment systems are inadequate to meet demand. The gap between projected needs and funding for drinking water infrastructure alone has been projected to be up to $267 billion over the 20-year period ending in 2020 (U.S. EPA, 2002). The situation for wastewater infrastructure is likely to be similar, and this gap is not expected to be filled by Congress.

Furthermore, much of the country (about 25% of all households, and 37% of new development) is served by on-site or decentralized wastewater treatment, often referred to as onsite systems or septic systems, but also including shared or cluster systems. The U.S. EPA has determined that "[a]dequately managed decentralized wastewater treatment systems are a cost-effective and long-term option for meeting public health and water quality goals" (U.S. EPA, 1997).

There are many appropriate uses for centralized systems. However, decentralized systems can also have advantages over centralized systems (Pinkham, Hurley et al., 2004):

- Decentralized systems can allow capacity to be more closely matched to actual growth in demand, thus delaying capital expenditures and targeting them more closely to real (as opposed to forecasted) needs.
- Decentralized options give communities more strategies for growth management, as facilities can be built where the need is without "inducing" growth along a long sewer corridor.
- Decentralized systems can recharge water tables and maintain stream base flows. The effluent from decentralized systems recharges the local ground water. Decentralized systems also generally do not suffer from infiltration and inflow, which can cause localized "dewatering" of the ground by sewers and problems with capacity at the treatment plant.
- Decentralized wastewater systems provide opportunities for cost-effective local reuse of water, since the distance from treatment to point of use is shortened.
- The risks and costs of wastewater system failure are likely to be less for decentralized systems than centralized systems; consequences of failures of small systems are limited, while the consequences of failures of large systems can be severe.

Decentralized systems are reasonable alternatives in many situations. Nonetheless, it has been the experience of the authors and many of the people interviewed for this report that decentralized alternatives are ignored or cursorily dismissed in situations where they may be at least as cost effective as any centralized alternative.

Why do decentralized solutions continue to be discounted and ignored by engineers of all types when looking for solutions to existing environmental and public health concerns or when considering how best to provide services to new development? More importantly, once the answer to this question is understood, what actions can be taken to create a more equitable and balanced setting that encourages engineers to pick the right solution for the challenge at hand, whether that solution is centralized or decentralized? The goal is not to create an advantage in favor of decentralized infrastructure, but rather to remove the barriers that exist so that engineers, and thus society, will consider all solutions equitably and use the most effective one.

Many barriers to the utilization of decentralized wastewater treatment alternatives have been identified, from a patchwork of different regulations to lack of access to public financing (Crosby and et al., 1998; Daborn, 1997; Fastenau et al., 1990; Nelson et al., 2000; U.S. EPA, 1997). The emphasis of this report is on engineers and what they can do in their professional practice to move towards more equitable consideration of decentralized systems. Unless otherwise specified, the term "engineer" refers to an individual trained in a branch of engineering that encompasses wastewater treatment, such as civil engineering or environmental engineering. Many other disciplines are involved in erecting the barriers that will be presented and considered, including (among others) financial institutions, political groups and elected officials, regulators, developers, and planners. However, in all sectors, engineers play a central role in these decisions and are best suited to remove the barriers identified.

Removing the barriers will require engineers to become leaders, not followers. This will challenge the industry and will require a change in thinking. From what engineers learn to how they perform their jobs, this report calls on them to apply the principles of their creed (NSPE, 1954):

"As a professional engineer, I dedicate my professional knowledge and skill to the advancement and betterment of human welfare. I pledge: ... To place service before profit, the honor and standing of the profession before personal advantage, and the public welfare above all other considerations"

By focusing on engineers, the recommendations in this report offer engineers ways to become the drivers of change in considering the most cost-effective, environmentally responsible manner to provide needed infrastructure. With their leadership the overall cost of meeting environmental challenges and thus the funding gap can be reduced. If the costs and impacts of developing methods of treatment to serve a growing society can be better managed, engineers will truly be providing the most sustainable recommendations to their clients and the public at large.

The project's initial phase, identifying barriers, encompassed *all* barriers, without judgment of whether engineers have a role in overcoming them. In the second phase of the project, ways to *overcome* the barriers were developed based on what actions different types of engineers could accomplish. Types of engineers considered included:

- Consulting engineers
- Regulatory and other public sector engineers
- Municipal and utility engineers
- University engineers (teachers, researchers)
- Manufacturers' engineers
- Engineering societies and similar organizations (a list and description of those considered is found in Appendix G).

The project team crafted a long list of strategies and actions for overcoming barriers, based on information from interviews, the literature reviewed, input at conference presentations about the project, and their own experience. The list was shared with WERF (including the Project Subcommittee) and members of a Stakeholder Sounding Committee who were assembled to review ideas (see Acknowledgements). Feedback from WERF's Project Subcommittee and the Stakeholder Sounding Committee (SSC) was used to greatly narrow the strategies and actions to be included in this report. The team conducted further interviews and other research to more fully describe the strategies, actions, and parties responsible for making the actions happen. Finally, each strategy was further scrutinized to consider financial ramifications, unintended consequences, regulatory impacts, and other implications that might indicate that overcoming one barrier could erect another.

This project's research generally has not investigated whether purported barriers are empirically true. For instance, the claim is often made that funding is more available for centralized options than for decentralized ones, and there is some anecdotal evidence to this effect, but the project did not attempt to validate or disprove whether this is generally the case. Rather, the report documents the perceptions of professionals around wastewater decision making and uses those perceptions to construct the list of barriers.

1.1 How to Use This Report

This document is organized to walk the reader quickly through the issues from barrier identification to actions. The remainder of this chapter peels away the scores of barriers that were identified to those few that meet several tests:

The barrier is a primary driver of the problem. In other words, if these barriers are removed, many other barriers will be influenced positively. Overcoming these barriers will deliver the most "bang for the buck" in terms of influencing engineering practices.

The barrier can be affected by engineers. This work is focused on what engineers can do. While there are barriers outside the influence of engineers that affect decision making on infrastructure choices, those barriers that can be affected by engineers will be the focus of this report.

The barrier is a major barrier. Of those that meet the first two tests, these are considered to be the most important ones that, once accomplished, will allow engineers to move on to the next wave of remaining barriers.

This chapter includes a description of the methods used in barrier identification, describes the four barrier categories, and then presents some representative case studies that were used to identify the barriers. Chapters 2.0 through 5.0 detail the strategies and actions the project team identified. Each action described in these chapters includes ***steps*** that engineers can take to realize the action, ***implications*** of the action (including possible regulatory impacts and unintended consequences), and a ***measure of success*** for the action. Chapter 6.0 contains communication plans for building and supporting champions, and summarizes the strategies and actions in a way that makes it easy to pick out who the responsible parties are. The chapter also provides an overview of the project's outcomes and lists actions that can be taken by specific types of engineers.

All the ideas and the process documentation about how this report came to focus on the barriers listed are provided in the appendices:

- Appendix A describes the approach used in this project.
- Appendix B documents the literature search used as part of the approach to identifying barriers.
- Appendix C describes how the initial list of barriers and categories was narrowed to the most influential ones.
- Appendix D gives a complete list of the most influential barriers found—not just those for which this report identifies strategies and actions.
- Appendix E provides a list of all the barriers which were identified through interviews and research in the initial phase of this project.
- Appendix F shows how each of the most influential barriers is addressed by strategies and actions in this report.
- Appendix G describes the engineering societies that were investigated as possible organizations to further some of the actions described in the report. Where the report refers to "engineering societies" but does not name specific societies, associated organizations can be found in this appendix.

1.2 Influential Barriers to Equitable Consideration of Decentralized Wastewater Treatment

Barriers were identified using a literature study, input from the WERF Project Subcommittee, input from participants in a NOWRA forum, and in-depth interviews of 25 key stakeholders (see Appendix A). The project team categorized the barriers, and four influential categories of barriers to engineers giving decentralized wastewater treatment equitable consideration were found:

- Engineers' financial reward for using centralized systems
- Engineers' lack of knowledge of decentralized systems
- Unfavorability of the regulatory system for decentralized systems
- Lack of systems thinking applied to wastewater issues

The barriers in this section are the most *influential* and *solvable* problems identified in this project. The most *influential* barriers were identified at the end of the project's first phase. In the second phase, *solutions* within each barrier category were proposed and evaluated by the project team and others. The strategies and actions were evaluated both on the basis of their potential effectiveness and on the extent to which they lay within the purview of engineers. The barriers below correspond to solutions that rated most highly in the evaluation. (A full list of the barriers can be found in Appendix E.)

This project's research generally has not investigated whether purported barriers are empirically true. For instance, the claim is often made that funding is more available for centralized options than for decentralized ones, and there is some anecdotal evidence to this effect, but the project did not attempt to validate or disprove whether this is generally the case. Rather, the report documents the perceptions of professionals around wastewater decision making and uses those perceptions to construct the list of barriers.

Some of the issues identified are not necessarily direct barriers to equitable consideration of decentralized systems. Rather, they are barriers to implementing the appropriate kind of decentralized system or establishing effective management. These barriers reflect problems that result in inadequate systems. Inadequate systems ultimately trigger another barrier—reduced interest in decentralized systems because of real or perceived failures.

1.2.1 Engineers' Financial Reward for Using Centralized Systems

This category of barriers is related to the other categories in a number of important ways. For instance, decreased financial reward for decentralized leads to:

- *Reduced engineer knowledge of decentralized systems*. Engineers are more likely to seek out information and gain knowledge about decentralized wastewater systems if they perceive it to be in their financial interest to do so.
- *Reduced use of systems thinking*. If engineers believe in general that decentralized systems provide less financial reward, they are less likely to spend time exploring ways that decentralized systems can provide multiple benefits to clients, communities, and the environment.

The research identified a large number of barriers in this category. As a result, these barriers were sorted into subcategories. The most influential and solvable barriers were found in two subcategories:

- Demand issues
- Funding availability and conditions

Demand Issues

A large number of barriers identified in the research had to do with the communities and decision makers that engineers serve, rather than the engineers themselves. These barriers are factors that affect the willingness of clients to invest in consideration of decentralized systems. Clients may be the clients consulting engineers work for, or the decision makers of towns or utilities that public sector engineers serve. These factors are barriers to equitable consideration by engineers because without willing and funded clients, engineers do not have the opportunity or the need to identify and consider decentralized systems. This subcategory includes the following barriers:

- Few funding programs require thorough consideration of decentralized options.
- Attitudes of regulators and municipalities do not support or help create demand for decentralized systems.
- Clients and the public do not have sufficient knowledge of decentralized options and their characteristics to request engineers to consider them.

- Clients do not see the added value decentralized can provide (e.g., avoiding the financial commitments of centralized capacity, preserving community character).
- Financial institutions that fund wastewater projects prefer to deal with municipalities, not individual homeowners, and municipalities may not be prepared to assume financial responsibility for onsite systems.
- Strong fiscal pressures exist to increase the number of connections to existing centralized systems, which discourages municipalities from working with decentralized systems.

There are many reasons why engineers' clients may not be interested in decentralized wastewater systems. In some cases there is simply a lack of awareness of decentralized options and the benefits of decentralized wastewater system architecture. In other cases, the clients (including the general public in many instances) have negative perceptions about decentralized wastewater systems. For instance, some developers believe that decentralized systems put more restrictions on subdivision and lot design and the resulting lots will not be as readily sold as lots with centralized sewers (Pinkham et al., 2004). Many property owners see decentralized systems as less desirable than sewer connections (Pinkham et al., 2004; Nelson, Dix, and Shephard, 2000).

Clients are also often concerned about broader implications, real or perceived, of decentralized systems. They may believe that using decentralized systems requires greater government involvement in private lives, or worry about burdens that could be placed on a community's tax rolls if a publicly funded decentralized system fails. One interviewee who works with many small communities had this to say:

> People live in rural areas because they don't want to deal with the government. The municipal officials in these areas are no different than anyone else. They think, 'Oh my gosh, I'm going to have to go on my brother's land and tell him to pump his septic tank.' Or to tell him that we'll take his land by eminent domain to connect three homes to a drainfield there. The combinations or permutations of negative interactions are immense in their minds. They're going to get enormously involved in people's lives when the only involvement they've had in the past is in plowing their roads in the winter. It scares them to death. But what scares them worse is a $93 [monthly] sewer bill. Communities are often stuck between two unfavorable options—involvement in residents' property and lives, or paying a whole lot more for a centralized system that minimizes that.

Communities may be unsure of many aspects of decentralized systems, and if technical and managerial assistance is not available, or communities cannot afford to purchase assistance from their consultants, they may be disinclined to consider decentralized options.

In some cases, fiscal pressure may discourage interest in decentralized systems. For instance, a community that has debt service requirements for a centralized system may feel pressured to extend sewer to increase the customer base. When fiscal considerations are paramount, fair and equitable consideration is unlikely.

Funding Availability and Conditions

Favorable funding is important to consideration and selection of wastewater system options. If engineers or their clients believe a decentralized wastewater system cannot be adequately funded, it is less far likely to be considered. There are a number of barriers to equitable consideration of decentralized systems that are related to funding:

- Funding is more readily available through conventional public funding channels for centralized systems.
- Homeowners prefer private ownership, but funding agencies prefer public ownership.
- Funding agencies lack familiarity and experience with decentralized systems or management.
- Use of public money on private land is legally and administratively problematic.
- Availability of grants for centralized systems but not for onsite systems distorts life cycle costing (LCC), making centralized appear cheaper.
- Funders' conditions, administrative structures, and biases favor use of traditional, centralized approaches.
- Engineers steer clients in particular directions for funding, usually toward familiar programs oriented toward centralized solutions.

Chapter 2.0 discusses these barriers in further detail. In brief, it is widely believed in the decentralized wastewater field that funding is more available for centralized than for decentralized systems. Programs that provide funding assistance, such as grants and low-interest loans, may not be set up to provide money for systems that differ from the sewer and central treatment plant norm. Program conditions and the knowledge and orientation of funding agency staff may not be favorable to decentralized systems. This includes problems with using public money on private property, where much or all of a decentralized system may be located, compared to the public right-of-way and public property locations of most centralized infrastructure.

It is also easier for funding organizations to deal with centralized projects. One interviewee observed:

> A lot of funding programs are run by engineers who come through centralized programs and are more comfortable with that. In some cases, there are a lot of logistic and administrative matters that make centralized more appealing to managers. Centralized projects tend to be a whole lot bigger. They would rather write a check for one system as opposed to many checks for decentralized systems for the same amount of people.

These issues are all important because if funding availability and terms differ between wastewater system options, this may "skew" the perceived economics of the options.

Some interviewees observed that affordability issues are beginning to draw more attention to consideration and funding of decentralized options. As one person said, "What's driving this thing is money. There's not enough money to have a centralized system for everybody at a reasonable price."

1.2.2 Engineers' Lack of Knowledge of Decentralized Systems

The lack of knowledge among engineers about decentralized technology and management is pervasive in the engineering community, including design engineers, regulators, utility engineers, developer's engineers and funding agency engineers. The barriers in this category include:

- Universities have limited or no curricula on decentralized technology and management.
- Documented knowledge of decentralized systems and their performance is not widely available.
- Research funding for decentralized systems is scarce, which reduces the amount and quality of university teaching about decentralized systems.

Decentralized technology is not normally taught in civil and environmental engineering programs. Faculty members who teach decentralized wastewater treatment estimate that fewer than 15 universities teach more than a partial course. When universities do offer courses on decentralized systems, the courses are usually in the agricultural engineering or public health engineering programs. Thus, most civil and environmental engineering students are not exposed to the concepts and technologies of soil-based treatment or decentralized systems.

Compounding the problem of few courses being taught is the lack of faculty instructors who are interested in teaching about decentralized systems. Instructors point to the limited funding for research, which results in researchers not working in the area of decentralized systems. As one professor pointed out, “We might think more about onsite systems if there was more money available to do research on them. Our interests are guided completely by what National Science Foundation and the research arm of WERF (Water Environment Research Foundation) fund, and that’s activated sludge.”

As engineers graduate and enter the engineering workforce they often progress toward professional engineering registration. The examinations for registration usually do not include problems in decentralized wastewater engineering.

Thus, as engineers practice wastewater engineering, they must develop their knowledge of decentralized systems through on-the-job training or from continuing education short courses. These short courses are available at some universities and through some professional organizations, such as the member agencies of the National Onsite Wastewater Recycling Association (NOWRA). Continuing education credits (CEUs) are required by some states to maintain engineering licenses, but not in all states.

1.2.3 Unfavorability of the Regulatory Climate for Decentralized Systems

Regulations and regulators are often unfavorable to decentralized systems. Quite a number of barriers exist within this category:

- Regulators’ perceptions and limited knowledge restrict equitable consideration of decentralized systems.
- Regulators need to better define what constitutes system failure and adequate performance.
- A weak regulatory environment can result in inadequate or failure-prone decentralized systems.
- Regulations and codes are often based more on regulating growth than good wastewater choices.

Regulations on decentralized systems are sometimes perceived as strict, ill-founded, or incomplete. This may make it harder for engineers to consider decentralized systems. It is also true that decentralized system regulations may be too lax in some places. One interviewee observed that "If regulators write rules so the least common denominator system can meet the rules, that's what you get."

However, these weak regulatory environments often result in inadequate or failure-prone decentralized systems. Such systems tarnish the reputation of decentralized wastewater systems, making equitable consideration more difficult in other communities. A related problem is that licensing and certification requirements—for system designers, installers, maintainers, and others—are sometimes overly restrictive, and sometimes are too loose or non-existent. This again means that equitable consideration may be difficult, or that systems may be prone to failure, and thus become suspect or discouraged as a long-term option.

Generally, regulations for decentralized systems are not tailored to the range of potential solutions. Most are prescriptive, and few entities allow performance-based programs or have requirements to manage such programs if implemented. Some states regulate discharge from larger decentralized systems as part of the underground injection rules, while other states have no regulations for these systems. Regulations for individual onsite systems also are usually well developed as opposed to those for larger decentralized systems or other multiple parcel solutions, which are not.

Finally, in many jurisdictions, codes and regulations for decentralized systems are sometimes used as an effective method to regulate and limit growth in rural areas, rather than being focused on improving wastewater management. In these settings, the best available decentralized technologies are not permitted, as they would allow development to take place in areas where planners wish to preserve forests or reduce development. This practice substantially interferes with equitable consideration among all wastewater options.

1.2.4 Lack of Systems Thinking

Systems thinking refers to defining the boundaries of a system to adequately encompass significant cause and effect relationships, and understanding the connections between the resources and activities within that system. For instance, systems thinking could be applied to combining wastewater treatment with reuse to address water supply issues, as during a drought. The system boundaries can be drawn to include both sources of water supply and uses of water. That way, both options that increase available supply and ones that reduce demand—perhaps even providing the same level of comfort and convenience—can be developed and compared.

Broad systems thinking in the wastewater facility planning process will increase the probability that engineers will give equitable consideration to decentralized systems, according to the premise underlying this category of barriers. Wastewater facility planning, for example, often addresses the impact on *water quality* of nutrients in wastewater, and how different wastewater systems (e.g., distributed septic tanks or centralized treatment and discharge) have different impacts on water quality. But wastewater facility planning rarely addresses the impacts of wastewater systems on watershed *water quantity*. Extensive sewering can result in the transport of large quantities of water (sanitary wastewater and groundwater inflow) over long distances, affecting the hydrologic balance of the "exporting" watershed(s). In the greater Boston area, sewer systems have removed so much groundwater that streams are suffering from inadequate summertime base flows (Pinkham et al., 2004). Decentralized wastewater systems, due to their local, typically soil-based discharge of treated effluent, can help maintain a pre-development hydrologic condition in a watershed. Engineers who use a wastewater facility planning process that took a systems thinking approach to the role of wastewater systems in the watershed would consider both water quality and water quantity issues, and would be more likely to give equitable consideration to decentralized wastewater options.[1] The Massachusetts Water Policy is a good, recent example of this type of approach (Massachusetts Executive Office of Environmental Affairs, 2004).

In addition to water quality and quantity, good wastewater facility planning takes into account population growth, environmental conditions, land use zoning and plans, other infrastructure such as roads and water distribution systems, and other local conditions and trends. It also addresses the impact of wastewater system decisions on those activities, conditions, and plans.

Broad systems thinking is not part of the standard engineering curriculum or the typical engineering culture. Engineers are exceptionally good at understanding components and relationships within the limited systems they typically evaluate. A wastewater treatment system is a system, after all, and engineers understand very well how these systems work. The problem lies in the drawing of system boundaries. Few engineers get training in or develop an orientation toward broader systems—the ecosystems, economic systems, and political systems present in a community or watershed in which an engineered system will operate.

The material that emerged from the research suggested the following barriers related to the lack of systems thinking in the wastewater facility planning process:

- Wastewater system planning and water resources planning are often not integrated.
- There is a lack of coordination between local government entities responsible for general planning and those responsible for wastewater infrastructure planning.
- Tendencies to focus on short-term costs rather than lifecycle costs hamper consideration of decentralized systems.
- Lack of robust alternatives analysis leads to less holistic solutions.
- Systems thinking is not part of the standard engineering curriculum or the typical engineering culture.

This list of barriers reveals many types of systems thinking considerations that can arise in the wastewater facility planning process. They include adequate understanding of a number of relationships: for instance, relationships between water quality and water quantity issues in a watershed; the relationships between wastewater planning, water resources planning, and general planning; the impacts of infrastructure on community growth and character; and the relationship of infrastructure choices to security issues. Adding systems thinking to engineers' training will help address these issues.

1.3 Case Studies

What does "equitable consideration of decentralized systems" look like? What are the consequences for communities and engineers when decentralized systems are considered equitably, and when they are not? The four case studies below illustrate examples where

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[1] The type of watershed water balance issue described here is not a consideration in all systems and watersheds, and decentralized systems are not always the best solution where hydrologic impacts of wastewater systems are a consideration. Nonetheless, this is one example of how systems thinking can affect technology choice.

equitable consideration of decentralized systems has been applied, some of the barriers encountered, and ways that barriers have been addressed. The case studies portray three different situations:

- One case study examines a community where decentralized systems *did not receive* equitable consideration. In Austin, Texas, city leaders asked the city water and wastewater utility to take a serious look at the role decentralized systems could play in providing wastewater service. The multi-year program encountered a number of obstacles, and decentralized systems did not become an important part of the utility's wastewater services.
- Two case studies highlight engineering firms that made decentralized wastewater systems engineering an important service offering. NorthStar Engineering is a small firm in Chico, California that illustrates how small firms can take advantage of the demand for decentralized wastewater systems generated by developers and small communities. The BETA Group is a larger firm (about 100 employees) with offices in three New England states that provides engineering of both centralized and decentralized systems.
- One case study describes a university where instruction is provided on decentralized systems for engineers. A two-credit course in the University of Wisconsin–Madison's Department of Biological Systems Engineering gives an introduction to the various types of decentralized wastewater treatment systems to engineering students, but it is taken by less than 10% of the engineering students who study water resource engineering.

These case studies help ground the premise of this research project: that engineers sometimes do not equitably consider decentralized wastewater options, but equitable consideration is possible and would assure that communities receive wastewater solutions that provide the best services and value. This study does not maintain that decentralized systems are a universal solution, but it does advocate full and fair evaluation of the range of potentially appropriate solutions for each community or property.

1.3.1 Austin, Texas[2]

The Community

Austin, the capital of Texas, is a growing city of about 657,000 as of the 2000 U.S. Census. The city's population makes up most of Travis County, population 812,000. The Austin Water Utility provides both water and wastewater service in the incorporated city only. Its wastewater system serves 168,000 connections. Treatment occurs at three plants with a total capacity of 130 MGD.

The Role of Decentralized Wastewater Systems

In the mid-1990s, as part of city initiatives for sustainable development, the city council asked the utility to evaluate a decentralized approach to wastewater management. City leaders

[2] This case study is based on interviews in August and September of 2005 with Sue Parten, President of Community Environmental Services, the consulting engineers to the Austin Water Utility decentralized wastewater management program; Crespin Guzman, an engineer formerly with the Austin Water Utility decentralized wastewater management program; and David Venhuizen, independent engineer; as well as web pages of the Austin Water Utility ("Decentralized Wastewater Program" at http://www.ci.austin.tx.us/water/).

believed that decentralized systems might be more environmentally sustainable and might better serve some of the city's growth management objectives (Guzman).

The utility established a decentralized wastewater management program. It appointed a utility engineer to lead the program and hired a local engineering firm to help implement a number of initiatives. These included studies of soils in developing areas, studies of decentralized wastewater treatment technologies, and a survey aimed at determining homeowner practices and preferences with respect to operation, maintenance, and management of onsite systems. The program also established several decentralized wastewater treatment demonstration projects. The overall goal of the program was to determine and advocate for roles that decentralized systems could play for the utility.

Barriers Encountered

The program manager and consultant quickly learned that extensive education of utility staff was required. Many staff members had never utilized a decentralized system in their own homes, and many of those that did use onsite septic systems at home had little knowledge of how these particular systems should be maintained, let alone how a utility should manage decentralized systems within its service area. Staff also had little idea that decentralized technologies can provide high levels of wastewater treatment.

As a result, the utility's engineering department was not interested in decentralized systems. They had their own way of providing wastewater service (install sewers and increase centralized treatment capacity as needed) and saw no reason to change. Moreover, utility managers were unwilling to commit many resources to developing decentralized wastewater systems and management capabilities. They often said to city leaders, "We don't have enough resources to manage our system as it is."

The program leaders also observed difficulties at the point of contact with homeowners and developers needing wastewater service. If a staff engineer who was interested in and knowledgeable about decentralized systems was assigned a case, decentralized options would be discussed. More often, a lack of knowledge or inclination on the part of staff engineers meant that decentralized options would not be discussed with property developers.

Patterns of growth and annexation also contributed to low levels of consideration of decentralized options. Annexations were typically of large areas. This favored extension of sewers as a way to quickly serve newly incorporated properties. In addition, new customers considered decentralized options "a second-rate solution." If they were going to pay city utility rates, they wanted centralized sewer service.

Status

In Austin, the decentralized wastewater approach never got off the ground. Areas once served by onsite systems have steadily had those systems replaced by sewer and decentralized options generally were not adopted for new development. The city's decentralized wastewater demonstration projects and its decentralized wastewater program are now in a holding pattern, with little ongoing effort or expenditure taking place.

1.3.2 NorthStar Engineering[3]

The Firm

NorthStar Engineering is a firm with about 30 employees in one office in Chico, California. The firm typically employs 10 or 11 licensed engineers, several land surveyors, and a variety of specialized and support staff. NorthStar works mostly in a four-county area around Chico. Its services include municipal infrastructure design, land development, onsite wastewater systems, surveying, and building design.

The Role of Decentralized Wastewater Systems

NorthStar's wastewater engineering practice is limited to decentralized systems. The firm does not pursue work on centralized, municipal systems. About 10 to 15% of its business is directly on decentralized wastewater systems. However, the firm sees substantial "job creep" into additional business—its decentralized wastewater expertise brings in other land development work that amounts to another 10 to 20% of the firm's volume. For instance, a developer working on a subdivision may contract with NorthStar to do all the work (survey, map approvals, etc.), since NorthStar has the expertise to deal with tough onsite wastewater projects. Developers also know that NorthStar has good relationships with regulatory agencies that will help clients achieve their objectives.

Barriers Encountered

NorthStar generally must train engineers on the job for decentralized wastewater systems. The firm is able to hire graduate level engineers from nearby Chico State University, but few have had much academic exposure to decentralized systems. A more senior engineer must mentor a new engineer, which often means that two engineers are doing one job until the new engineer is trained.

A key barrier encountered by Northstar is the lack of consistent onsite system regulations from county to county in California and between the nine regional water quality boards in the state. This has several impacts on the equitable consideration of decentralized wastewater systems. It is difficult for engineers to gain and maintain a good working knowledge of the regulations across many jurisdictions. Some technologies are not available in all locations because decentralized system manufacturers cannot afford to take their product through the approval process in so many jurisdictions. Another barrier stems from the inevitable cases of badly designed or installed systems that are approved in one jurisdiction because of lax rules or overtaxed local regulators. When these systems fail, it becomes difficult to obtain approval for the same technology in another jurisdiction, even though the fault is with design, installation, or maintenance, and not intrinsic to that technology.

NorthStar has found that county regulatory engineers often lack training in decentralized wastewater systems and that these regulators are spread too thin. California uses registered environmental health specialists to manage onsite permitting—individuals with responsibility for restaurants, dogs, cats, rabid bats, toxic spills, underground fuel tanks, and more, as well as onsite wastewater systems. Overtaxing personnel results in faster turnover and this exacerbates

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[3] This case study is based on interviews in August of 2005 with Mark Adams, President, NorthStar Engineering, and Ron Dykstra, Associate Water Resources Control Engineer, Central Valley [California] Regional Water Board.

the general lack of training of these regulators. This lack of training produces challenges in permitting systems and leads to more onsite system failures.

A related barrier is that regulators often expect a degree of perfection from decentralized wastewater systems that cannot realistically be achieved. Expectations for system conditions and performance tend to be unrealistic for decentralized systems, and over-permissive for centralized systems. NorthStar has observed that regulators may expect a decentralized system sponsor to prove a certain number of feet of separation to ground water, while allowing centralized systems to construct raw sewer lines below the groundwater table.

Status

NorthStar Engineering has established a successful niche in providing decentralized wastewater system engineering to clients in areas not served by sewers. Decentralized system engineering is a cornerstone of the firm's business. The firm's expertise and experience with regulators brings in substantial business. The firm has found that because of its reputation, it is often able to get property owners and developers to pay on a time and materials basis. Also, because it has plenty of work, the firm can afford to pass up some jobs in the bid market. These favorable circumstances ensure a decent profit and reduce economic risks.

1.3.3 The BETA Group[4]

The Firm

The BETA Group is an engineering firm with 90 to 100 employees in three New England offices—one each in Rhode Island, Massachusetts, and Connecticut. The firm provides environmental, transportation, civil-site and structural engineering, and environmental science. It conducts decentralized and small community wastewater system evaluations, including the state-mandated engineering and soils/geology studies needed for systems with flows of 10,000 gallons per day and more. BETA also provides engineering services for centralized wastewater collection systems and treatment facilities.

The Role of Decentralized Wastewater Systems

BETA does about 15 to 20% of its business in decentralized wastewater systems. Clients range from small towns, institutions, and trailer park owners to larger developers. BETA serves these clients with a combination of engineering, soils, and hydrogeology specialists. The staff works with regulators and follows new decentralized technology developments and their acceptance by regulators.

The firm only provides engineering services for cluster systems and small commercial/institutional systems. It does not consult on individual onsite systems for homeowners. BETA has found that individual homeowner work does not match well with their standard business practices, such as requiring a contract with every client, or seeking repeat business with clients. They see so little profit potential with each homeowner system that they do not pursue this market, leaving it instead to one-person and other small engineering firms.

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[4] This case study is based on interviews in August of 2005 with Joe Federico and Bob Baglini, engineers with The BETA Group, Inc.

Fees for most jobs in the cluster and commercial/institutional market are large enough to be of interest to the firm. Hydrogeologic surveys and soil evaluations conducted by the firm as part of the site evaluation and selection process can range in total fee from $25,000 to $125,000. In addition, most systems that are over 10,000 gallons per day in Rhode Island and Massachusetts involve advanced wastewater treatment and a permit from the state, so substantial engineering work is involved. The firm has found that planning, design, and construction supervision of decentralized systems can all be profitable.

Barriers Encountered

BETA has found that the availability of persons trained in decentralized technologies is low. Its engineers and scientists usually need to be trained on the job. Staff members receive continuing education through short courses offered by the University of Rhode Island and the University of Massachusetts.

The firm has found that regulators are demanding of engineering for innovative systems. While a number of technologies are now well-accepted, regulators require substantial studies and monitoring for decentralized technologies that are not familiar to them. BETA has also experienced a technical barrier in that it is difficult to find reliable equipment, particularly pumps, for small systems.

Status

Decentralized systems are a significant part of the BETA Group's wastewater engineering services. The challenging regulatory environment might be considered a barrier by many engineers, but BETA has found that this environment requires a significant amount of high-value engineering, such as design of larger decentralized systems that require advanced wastewater treatment. The regulatory requirements for cluster and commercial/institutional systems demand substantial engineering expertise, which is conducive to BETA's business and to training and maintaining a staff well-versed in current regulations and technologies.

1.3.4 University of Wisconsin's Engineering Education for Decentralized Wastewater Treatment[5]

The Program

The University of Wisconsin—Madison is the largest of the University of Wisconsin (UW) campuses, and has a large, well-established College of Engineering. Courses in wastewater treatment for engineering students are found in the Civil and Environmental Engineering (CEE) major. Wastewater treatment is taught as part or all of a number of courses:

- CEE 320 Environmental Engineering (required for all CEE majors; wastewater treatment comprises eight of the semester's 39 lecture periods)
- CEE 322 Environmental Engineering Processes (all CEE majors must take this course or Hydraulic Engineering; catalog description, "Combination of theory and laboratory practice

[5] This case study is based on interviews from August and September 2005 with Jim Converse, Professor Emeritus, BSE, Trina McMahon, Assistant Professor, CEE, Dan Noguera, Professor, CEE, and Greg Harrington, Associate Professor, all at the University of Wisconsin-Madison, and Chuck Johnson P.E., of C.G. Johnson Engineering.

to study basic unit operations and processes in environmental engineering. Emphasis on water and wastewater treatment processes, such as coagulation/flocculation, chemical precipitation, filtration, adsorption, activated sludge, anaerobic digestion, and substrate utilization kinetics.")

- CEE 426 Design of Wastewater Treatment Plants (Catalog description, "Unit operations in wastewater treatment; physical, chemical, and biological processes for treatment of wastewater; sludge treatment and disposal; design of a wastewater treatment plant; site visits to wastewater treatment plants.")
- CEE 821 Environmental Engineering: Biological Treatment Processes (Catalog description, "Advanced theory and applications of biological systems for the treatment of wastes; lab techniques to assess treatability and to provide design parameters.")

In the College of Agriculture and Life Sciences, Professor Emeritus Jim Converse teaches one two-credit course in decentralized wastewater treatment that is included in the Department of Biological Systems Engineering (BSE), and all BSE students enrolled in the Natural Resources and Environmental Engineering Option are required to take that course. The two-credit course in decentralized wastewater treatment makes UW–Madison one of a small number—probably no more than fifteen—universities in the country offering *any* courses in decentralized wastewater treatment.

In addition, UW–Madison has been home since around 1970 to a research and extension program focused on decentralized wastewater treatment: the Small-Scale Waste Management Program (SSWMP, pronounced "SWAMP"). The program was initially funded by the Wisconsin legislature after they passed a new decentralized wastewater code that tightened parameters for system design. The new program was intended to develop technologies that could provide adequate wastewater treatment. SSWMP is an interdisciplinary group that has included soil scientists, bacteriologists, engineers, virologists—and even an economist—who were interested in onsite wastewater treatment.

The U.S. EPA also funded SSWMP. One of the early fruits of the research was the so-called Wisconsin mound system, which provides a raised area for aerobic effluent treatment in sand to overcome limitations in the depth of native soil on certain sites. The mound system is now commonly used in many parts of the country to achieve adequate treatment where traditional systems would not function.

The Role of Decentralized Wastewater Systems

In the 1980s, Jim Converse first offered an undergraduate course in decentralized wastewater treatment, targeted at students planning to work in the construction industry. The one-credit course was half on water supply and half on decentralized wastewater treatment.

In 1997, Converse developed a two-credit course in onsite wastewater treatment, taught in BSE—the first one at Madison designed for engineering students. For that course he assembled selected publications that were distributed to students as photocopied sections in a three-ring binder and are now available on the web. The course attracts 15-20 students each fall semester, primarily from BSE and some from CEE. A few graduate students also usually enroll in the class.

The research conducted through the SSWMP program also allows training of graduate students. One was Chuck Johnson, who now runs C.G. Johnson Engineering in Massachusetts. Johnson studied for two years in the CEE and BSE departments to earn a master's in civil and environmental engineering, with his thesis research directed to understanding treatment efficiencies in sand filters. Johnson came to the graduate program with an undergraduate degree in civil engineering—though not including any wastewater classes—and 17 years of work experience, with 10 years focused on onsite systems. Johnson characterized the experience at Madison as "fantastic, everything I was looking for." Asked what he gained at Madison after so many years of working in the field, he said his graduate studies allowed him to be more creative in his designs and to be more authoritative in presentations—the master's degree in civil engineering with a thesis on sand filters impresses people.

Barriers Encountered

The situation at Madison shows that a vast majority of students studying wastewater learn only about centralized systems. Even at UW–Madison, where decentralized wastewater treatment is in the curriculum and has a research program, CEE students outnumber the BSE students by about 10:1. Only a few CEE students take the decentralized wastewater course each year, and decentralized concepts are mentioned in no more than 10 minutes of lecture in CEE courses related to wastewater treatment.

BSE 372 Wastewater Treatment has been cross-listed as a CEE course for a number of years now, yet few CEE students take the course. Both instructors of the CEE 320 Environmental Engineering course encourage their classes and the students they advise to take BSE 372.

The lack of research funding in the decentralized field makes it difficult for faculty to develop a depth of knowledge, and there are few choices for graduate programs.

Scarce funding for decentralized research also makes it difficult to recruit the next generation of teachers. Converse, already retired but still teaching the decentralized course, speculates that the university will find someone who can teach his course, but that decentralized will not be that person's focus because little research money is available.

It is not clear that the BSE students have much exposure to systems thinking encompassing the role of decentralized systems in watersheds or society. The program includes BSE 571 Watershed Engineering, but the course focuses on stormwater, not wastewater.

Status

Jim Converse and Jerry Tyler have been prominent researchers in decentralized wastewater treatment. Nationally recognized experts in the field have come through the program at Madison. With Converse retired and Tyler near retirement, the future of the program is uncertain.

Chuck Johnson, the recent graduate of the program, would like to see it expanded. He suggests expanding Converse's two-credit course to three credits and adding a supplementary course in design of decentralized systems. He sees the design course as working through options for a particular site and exploring how to handle the unexpected situations that occur once construction begins.

Fortunately, there are more resources now available for teachers, so faculty without Converse and Tyler's background can teach introductory courses. The Consortium of Institutes for Decentralized Wastewater Treatment has developed a curriculum, complete with reading material and PowerPoint presentations, which is available from their website.[6]

[6] http://www.onsiteconsortium.org

CHAPTER 2.0

INCREASING ENGINEERS' FINANCIAL COMPENSATION FOR USING DECENTRALIZED SYSTEMS

Research for this project identified a number of barriers related to a simple economic logic: If engineers receive greater financial rewards for using centralized systems, they are less likely to give decentralized systems equitable consideration. For instance, there is a common perception and often a reality that engineers receive smaller fees (total revenues) from decentralized projects than from traditional centralized projects. Centralized projects may generate greater requirements for engineering services because they serve more connections or are more capital intensive than decentralized options. Many decentralized system advocates believe that funding program criteria and conditions are biased against decentralized options; thus, if engineers cannot get decentralized options funded for their clients from standard sources, clients and engineers will not consider or use them. There will be few requests that decentralized options be seriously considered if key stakeholders do not understand decentralized wastewater technologies and their potential advantages These are just a few barriers that affect the financial rewards to engineers from considering and using decentralized systems.

"Financial rewards" are easiest to identify for consulting engineers. However, other types of engineers can receive direct or indirect financial rewards. Manufacturer engineers receive direct financial rewards if their technologies can be incorporated into decentralized system designs. Municipal engineers provide financial rewards to their communities when they design or select less costly systems. Agency engineers generate financial rewards for their agencies and society at large when they permit, fund, or otherwise assist decentralized solutions that are the least-cost option.

This chapter proposes solutions to financial barriers that will increase the financial rewards for engineers who give decentralized options fair consideration and use decentralized solutions when they are appropriate. The solutions affect both the "demand" for engineers to consider and provide decentralized solutions and the likelihood that engineers will "supply" decentralized solutions. For instance, if regulatory and funding agency rules and guidelines require serious consideration of decentralized options, this creates a demand that consulting engineers must respond to. If consulting engineers consider and adopt new business models that provide increased compensation for using decentralized solutions, they are more likely to supply those solutions to their clients.

2.1 Strategy: Increase Availability of Financial Assistance for Decentralized Systems

Municipalities, developers, and landowners who build or own wastewater systems will not be receptive to decentralized options if financial assistance is unavailable for these options but is available for centralized options. This is often the case, and it contributes to consulting engineers' reluctance to use decentralized systems. If clients cannot get financial assistance for planning and building these systems, consulting engineers will not get paid to consider and specify them and will tend to favor other systems. There is a strong feedback loop between funding availability and the profits of consulting engineering firms: when funding programs favor certain types of systems, more profits will come from those types of systems. Engineers will therefore specify those systems more frequently, which will drive community demand for funding for those systems and will often result in dedication of more funding to those systems.

It is essential for additional reasons that the "playing field" for public financial assistance be as level as possible. If assistance is available for one type of system and not another, the cost to the user may be lower for the subsidized option, even though the total cost of another option is less. The subsidized system appears less expensive, and it is for the local community but not for society as a whole.

In many states the project review and ranking criteria within important wastewater infrastructure funding programs are biased toward centralized systems. The first action below addresses this situation. The solution can include dedicating more funds specifically to decentralized options. Another key funding barrier is that financial assistance may be difficult to direct to individual property owners, for practical and legal reasons. Two actions below provide ways around this barrier.

2.1.1 Action: Implement Funding Set-Asides and Project Review and Ranking Criteria That Remove Biases and Encourage Greater Use of Decentralized Systems

The U.S. EPA-funded Clean Water State Revolving Fund (SRF) is the largest source of funding for wastewater projects in most states. The U.S. EPA established a scoring structure for prioritizing and awarding loans under state SRFs, although states have some discretion to adapt the structure and the point system. In many states, this system still reflects its origins as a scoring system for centralized wastewater treatment plants with surface water discharges.

In the state of **Vermont**, which has the highest percentage of use of decentralized systems in the U.S., funding for wastewater systems is awarded on the basis of priority points. Of the 47 points available in seven point categories, nine points apply only to discharges to water quality limited surface water segments; 10 points apply only to combined sewer overflows to lakes, ponds, and streams; seven points apply only to elimination of raw sewage discharges to surface waters; and six points apply only to elimination of primary treatment discharges to surface waters or improvements necessary for a plant to meet effluent limits. Thus, 32 of 47 points are not available to decentralized systems with soil discharge. Under this system, priority is clearly given to areas that have a conventional centralized system that is failing or inadequate in some way, notably phosphorus removal. This means that SRF resources will not be directed to areas with decentralized systems that are failing, but will be focused often on Total Maximum Daily Load (TMDL) driven limits for nitrogen, phosphorus, or other pollutants of concern. Furthermore, since there is no Nonpoint Source Discharge Elimination System (NPDES) program jurisdiction over onsite systems, an NPDES driver for providing funding to onsite systems is lacking.

Some states have used one or both of two key approaches to resolving the historical bias towards traditional centralized systems with surface water discharge. One approach is to set aside some SRF funds for non-point source problems or specifically for decentralized wastewater systems. **Rhode Island** has taken this approach in its Community Septic System Loan Program (CSSLP; http://www.ricwfa.com/CommunitySepticSystemLoanProgram.html). Established in 1999, CSSLP sets aside federal money recycled from previous Clean Water SRF loans in order to fund decentralized system improvements in communities without conventional wastewater treatment facilities. A community must first have an On-Site Wastewater Management Plan adopted by the local legislative body and approved by the Department of Environmental Management. Once its plan is approved, the community negotiates a loan with the Rhode Island Clean Water Finance Agency, and then makes the funds available to residents through low-interest (2%) loans.[7]

Massachusetts has made some SRF funds available only through the Community Septic Management Program (CSMP) (Massachusetts DEP, 2005). Funds are disbursed to communities, which then provide loans to individual homeowners for the repair, replacement, or upgrade of failed systems. Since inception of the program in 1997, nearly $52 million in funds have been disbursed to borrowers in 140 communities (Pat Deal, Treasurer, Massachusetts Water Pollution Abatement Trust, personal communication). The CSMP is not strictly limited to retaining onsite systems—homeowner sewer connections are also eligible—but most of the funds, reportedly about 80%, do go to projects that retain onsite systems (Pamela Truesdale, Southeast Regional Office, Massachusetts Department of Environmental Protection, personal communication). Decentralized wastewater projects can also compete against conventional projects within the regular SRF program, but the CSMP ensures that communities with a need to replace or upgrade onsite systems have a place to go for funds.

Another approach is to revise the project ranking system to remove biases toward conventional centralized systems. **Minnesota**, for example, recently recognized that its priority ranking system used to establish the Project Priority List under its SRF led to larger and larger "big pipe" project proposals that required large subsidies to be affordable (Freeman, 2006 personal communication; Freeman and Dunn, 2006). There were several contributing factors to this situation. First, minimal documentation requirements for existing conditions meant that areas without severe problems could be included in project funding applications, leading to larger than warranted projects. Second, the density of the "problem area" was used for project ranking, while the "project area" could be four times larger, leading to large projects being funded with only part of the area being high density. Finally, bonus points were given for projects that regionalized wastewater systems. In response, the state has modified the project priority system. Changes made included assigning points based on the operating condition of existing septic systems, modifying the density factor to require that 90 percent of the structures served be located within the project's impact zone, and requiring thorough review of conditions in unsewered areas. Additional changes to the state's funding programs included revisions to the Minnesota Rules Chapter 7077 facility plan alternatives analysis hierarchy for unsewered areas (see Section 2.2.1). Also, a state-funded program for supplemental project funding that was deemed to over-subsidize large projects was changed from a grant program to a zero-interest deferred payment loan program to reduce incentives for large projects.

The important Water and Waste Disposal Loan and Grant Program of the **USDA Rural Development** program uses a points ranking system that is less biased toward centralized

[7] This is an example of an SRF "conduit lending" or "pass-through" program, which is discussed in more detail in Section 2.1.2.

systems than many SRF programs. Most points are awarded on the basis of community size, health priorities (specifying only that favored projects correct "inadequacies of a wastewater disposal system"), median household income, amount of other funds committed to the project, service to an Agency-identified target area, and other system-neutral criteria. Only one criterion is more likely to apply to centralized systems than decentralized ones: "Project to enlarge, extend, or otherwise modify existing facilities to serve additional rural residents" (Rural Utilities Service, 2003).

Worthwhile revisions to funding rules can include establishment of specific criteria, such as practices and thresholds that must be met for financial assistance to be provided. These would ensure that only "smart" projects are funded. Revisions can also include changes to funding prioritization schemes that would ensure decentralized options receive their "fair share" of public funds.

Basic provisions of funding programs should emphasize sound long-term financial planning and asset management for all wastewater systems, and could include:

- Criteria requiring that submitted facility plans adequately consider decentralized options, so no potentially cost-effective approaches to wastewater service are missed. This reemphasizes the approach in Section 2.2.1.
- Criteria requiring that the option presented for public financial assistance is the most cost-effective option that meets public and environmental health requirements and any other clear—and clearly evaluated—objectives. Cost-effectiveness should be based on a life-cycle cost analysis, a point discussed in Section 2.2.1.
- Criteria or ranking factors that favor options that do not require growth in the number of connections to be financially viable. This approach requires that documentation of the proposed option clearly shows all financial assumptions. Such options put public funds at less financial risk, since there is no reliance on growth that might not occur. Decentralized systems often out-perform centralized ones in this respect (Pinkham et al., 2004).

Additional funding program provisions that would emphasize reducing total social costs, and thereby would often elevate decentralized options, could include:

- **Ranking factors that favor options that show integrated water resource management benefits**. For instance, a decentralized option may allow lower density development than a centralized one. As a result, it may have reduced peak runoff impacts on local streams due to reduced impervious surfaces, and may require less new stormwater infrastructure. See the systems thinking strategies and actions in Section 5.2 for further thoughts on the importance of an integrated water resource management approach.
- **Ranking factors that incorporate relative health and environmental risks**. While all options advanced to the funding stage should meet regulatory requirements, the relative risks of each may be dissimilar. For instance, in some areas there may be less risk of nutrient loading to local surface waters from decentralized systems that allow for nutrient uptake by soil and plants than from a centralized surface water discharge that does not incorporate expensive nutrient removal technology.

Steps

SRF set-asides for decentralized wastewater systems and other distributed approaches to water quality management are now voluntary. Some advocates of the decentralized approach to wastewater management have recommended that these set-asides become mandatory (Nelson, 2005). Unless and until this occurs, lobbying at the state level will be needed to establish SRF set-asides. In the absence of federal action, state level efforts are also necessary to revise project review and ranking criteria.

The most likely targets for state level action are the state agencies responsible for funding wastewater infrastructure, particularly those that manage SRF funds. Action could be initiated by personnel within the agency or agencies, or by outside parties such as a sub-group of a professional engineering society concerned with state wastewater infrastructure funding rules and practices. In the latter case, it is likely that engineers from smaller firms who currently do significant decentralized wastewater work would be the instigators, as they would be more likely to benefit than engineers from larger firms.

In many states, funding agencies work in concert with regulatory agencies to review projects proposed for funding. In such cases, both the regulatory and funding agencies must be engaged. Engineers in regulatory agencies are ideally situated to evaluate and even develop project review guidelines that will more fairly allocate limited funds.

Politically appointed agency leadership could initiate the required efforts. Unfortunately, they can also stand in the way of change. Engineers and engineering societies should approach the politically appointed leaders of funding and regulatory agencies to ensure they understand the need to provide access to funds for decentralized solutions. It will help if agency leaders who are early adopters of the needed changes are highlighted around the country in publications respected by their peers. Visibility of positive political leadership will go a long way to making similar action in other states viable. Where politically appointed agency leaders remain obstacles, legislative action may be required to force change.

Implications

As decentralized systems are evaluated equitably, the intersection of these systems with stormwater solutions will become apparent. For example, in regions of the country where reuse of effluent from decentralized systems is practicable, it may be used in conjunction with low impact development strategies associated with distributed stormwater management to assure low cost maintenance of landscaping, low stormwater volumes released from a site, and one integrated system. In such cases, access to funding sources that have historically been segmented between *either* wastewater or stormwater may be appropriate to use for both, or even a blend of funding from each source may provide the incentive to fully integrate systems. Grant programs and SRF decision making may need to become integrated to ensure that states are gaining the best return on investment from all sources. Further, changes to evaluation criteria to "level the playing field" for decentralized systems could force some states to reevaluate funding allocations for decentralized options.

Should states decide to integrate funding options for wastewater (decentralized and centralized) and stormwater, current project ranking systems will likely prove inadequate and or require some modification to ensure that an understandable, transparent, fair system covers both a wide array of types of projects and the disbursement of various loans and grants. New ranking systems, though more complex, would provide regulators and funders the potential to better leverage the funds at their disposal by considering costs and benefits across project types and funding mix, so that the most beneficial projects rise to the top. In addition, integration of funding options would (or at least, should) encourage integration of solutions and would let decision makers consider how to mix and match loans and grants to create enough enticement to move forward.

Programmatically, such a new direction will require real change. The majority of projects funded today are those with surface water discharges. Since decentralized options (for both wastewater and stormwater) often utilize soil-based treatment and discharge to ground water, funding programs will need to be convinced to value groundwater recharge, or at least the avoidance of a direct discharge, as a positive. Groundwater regulatory programs will need to examine and remove their own barriers as well. Only then will decentralized projects compete successfully in scoring systems.

Measure of success

This action will have succeeded when most funding programs have review and ranking criteria that are likely to give a "fair share" of funding to decentralized projects, and a significant upturn in the number of decentralized projects funded in each target program occurs.

2.1.2 Action: Implement New Loan Fund Models

One important way to get financial assistance to onsite and decentralized system owners is through subsidized loans. Such loans reduce the cost of money for individual property owners who foot the bill for all or much of a decentralized system's cost. This has several effects that are linked to "leveling the playing field" by making the cost of money for decentralized systems more similar to that for centralized systems, which frequently benefit from subsidized loans. Because this approach directly benefits property/system owners, it increases the relative attractiveness of decentralized systems, ultimately increasing demand for such systems. This increased demand for decentralized systems translates to increased work for engineers, resulting in increased financial rewards for considering decentralized options. It also allows for a more "apples to apples" comparison of the total social cost of decentralized and centralized approaches, which should include the cost of money as one cost component.

There are several models for loan funds that include lending directly to individual property owners for decentralized systems. They include:

- "Conduit lending" programs in state clean water revolving loan funds
- Inclusion of onsite systems in loan funds directly targeted at individual property owners.

Conduit lending refers to arrangements in which a state allows for lending of SRF monies through intermediaries to entities—particularly individual property owners—that implement actions that serve the objectives of the SRF program. A number of states such as Ohio have set up "linked deposit" programs in which banks loan SRF funds directly to individual property owners. The state SRF agency provides funds to the bank in the form of a certificate of deposit at a sub-market interest rate. The bank then administers the financial aspects of loan processing and lends money at a low interest rate to homeowners and others needing to replace or upgrade a septic system. The bank's services are paid by the spread between the low loan interest rate it receives and the lower CD interest rate it pays.

Another conduit lending arrangement, called a "pass through" program, involves the state SRF agency providing money to another government agency, which then lends directly to individual property owners. The conduit agency could be a municipality or sanitation district. EPA's Environmental Finance Board recently supported this idea, noting that the local agency could make funds available at an even lower cost than banks. Local agencies could also claim offsets to pollution loadings from centralized facilities through the non-point source improvements funded by such lending (U.S. EPA, 2003).

Establishing linked deposit and pass-through programs requires adjustments to the rules and practices of individual state SRF programs. Nine states have developed linked deposit programs, and 15 have developed pass-through programs (Stephanie von Feck, Clean Water State Revolving Fund Coordinator, U.S. EPA, Office of Wastewater Management, personal communication).

Another option is to include onsite systems in loan programs that are already designed to lend to individual property owners. Loan programs funded by state development agencies or the U.S. Department of Housing and Urban Development (HUD) are good candidates. For instance, Vermont's Agency of Commerce and Community Development (ACCD) provides a grant to the Central Vermont Community Land Trust (CVCLT) to provide low-income homeowners with low-interest loans for home repair projects in three Vermont counties (Jim Saudade, Deputy Secretary, Vermont Agency of Commerce and Community Development, personal communication). Eligible projects include replacement of failed onsite wastewater systems. The state funds come from HUD through the Community Development Block Grant (CDBG) Program. CVCLT administers all loan processing aspects of the program and provides assistance to homeowners in working with contractors, consulting engineers, and town engineers. The program is designed to serve homeowners who would not be fundable through commercial banks. Another source of funds used for similar programs by other Vermont towns is the Housing Preservation Grant program of the USDA Rural Development agency (Garrath Gorton, Central Vermont Community Land Trust, personal communication).

Steps

In many states there are likely to be untapped opportunities to use SRF conduit lending and non-SRF loan programs to provide financial assistance directly to individual property owners. In many cases this action will need to be initiated outside of funding agencies. While EPA promotes linked deposit and pass-through programs, action on the part of state SRF agencies is more likely if communities that need funding for individual properties but cannot get it through conventional programs take their cases directly to the funding agency.

Consulting engineers familiar with the financial needs of towns they serve would be excellent facilitators of these efforts. These engineers would benefit from having municipal clients who would be more likely to get decentralized projects funded. Consulting engineers who have relationships with funding agency personnel could be effective in "lobbying" these personnel for change. If engineers act through a statewide professional engineering association, this would be a particularly powerful approach.

Given the publicity linked deposit and similar programs have received, advocates may find that funding agencies are receptive to the necessary changes, but that taking action may be a low priority. Advocates may find it useful to approach legislators, present their case, and ask legislators to take their case to funding agency leaders.

A potential obstacle lies in finding local entities to take on the loan administration responsibilities. Existing conduit lending programs provide models for success. For instance, Ohio's linked deposit program has used county Soil and Water Conservation Districts (SWCDs) to help enlist banks in the program. Program personnel work with SWCDs in the watershed planning process, and the SWCDs in turn get local banks interested in the program. Program personnel then meet with the banks individually or in groups to provide further information and answer questions. Also, often the SWCDs can identify good customers of the local banks who can approach the banks and request that they participate so that the customers can access this source of funds (Bob Monsarrat, Manager, Environmental Planning Section, Division of Environment and Financial Assistance, Ohio EPA, personal communication).

Implications

Regulatory and funding decision makers will often be concerned with the appropriateness of providing public funds to systems that are privately held. The argument that the lowest cost investment is being chosen must be compellingly made to overcome this resistance. Consulting engineers can clearly play a large role in making this argument, using cost comparisons from previous and current work when making generic, policy-level arguments, and cost comparisons from current studies when supporting the argument for using public funds for the projects identified in those studies.

With both the new loan fund model action and the set-aside action (Section 2.1.2), as decentralized options increasingly compete for limited water quality funds, or move outside the limits of environmental agencies to HUD and other sources, stakeholders already utilizing these funding sources may feel challenged and attempt to stop change. For instance, if a state is not currently funding decentralized options through its SRF program, the centralized program constituency may see a decentralized loan program backed by the SRF as a threat. This could even result in conflicts within the engineering community between engineers who serve large communities with centralized systems (typically larger firms) and those who serve small communities with decentralized systems (typically smaller firms).

However, in practice, this may not be a significant issue. It will often be possible for engineers and others to argue that the funds being directed to decentralized wastewater options are a very small fraction of the total funding available. For instance, in Ohio, where a robust linked deposit program has been in place for some time, that program still accounts for less than one percent of all funds loaned since inception of the SRF. Another strategy is to utilize less-scrutinized funding sources. The Ohio linked deposit program, like the Rhode Island CSSLP program described previously, uses as its funds source the unobligated repayments of previous SRF loans (Bob Monsarrat, Manager, Environmental Planning Section, Division of Environment and Financial Assistance, Ohio EPA, personal communication). This funding source is typically less "in demand" than "first-round" SRF funds, and may be a good source to consider for other states seeking expanded funding for decentralized options.

Another implication of the successful implementation of this strategy is that more private properties would be served by onsite or other decentralized systems, rather than being connected to centralized sewers. The issue of onsite system management will become more critical in states where it has not adequately been addressed. Thus, state funding and regulatory programs may need to determine how to best regulate decentralized systems after construction. Assurance of proper management, perhaps through a requirement for incorporation of funded systems into onsite management districts, may need to be a condition for providing funds to banks and local governments who pass on the funds to private property owners. Engineers who serve the communities where these funds are used should participate in development of responsible management entities (RMEs), decentralized municipal utilities, and other such organizations and mechanisms. It will be in their financial interest to do so—engineers who design onsite systems may be able to provide paid advice on development and operation of the appropriate entities and management mechanisms, will be able to sell more design work in these communities, and may be able to provide O&M and management services in these communities (see Section 2.4).

Measure of Success

This action will have succeeded in each state without such programs when one or more funding programs are put in place and those programs are used successfully by multiple municipalities or sanitation districts.

2.1.3 Action: Establish Tax Credits for Onsite System Upgrades

Tax credits are an effective means of subsidizing actions deemed to be of social value. Establishing tax credits for onsite system improvements under certain conditions would help offset engineer and municipal preferences for centralized systems due to the availability of grants for such systems.

Massachusetts has an income tax credit in place for the repair or replacement of a failed cesspool or septic system. Up to 40% of the cost of a system can be claimed to a total of $6,000, with a maximum credit of $1,500 in any one year for up to four years. The taxpayer claiming the credit must occupy the subject property as his or her principal residence. The credit is reduced if the applicant also receives a state-funded loan for onsite system repair or replacement. This credit was established to help defray the costs to homeowners of the "Title 5" revisions to the state onsite system code enacted in 1995 (Massachusetts Department of Revenue, 2006), which required onsite system conformance with the code as part of clear title to a property at the time of sale.

Onsite system tax credits could also be targeted to improvements in high-priority public and environmental health problems. This might include addressing "straight pipe" onsite systems or upgrading onsite systems in high-priority impaired watersheds.

As in Massachusetts, these types of tax credits are probably best implemented through the state income tax system, rather than through local property tax systems. The costs would then be spread across a larger tax base and issues of favoritism to specific individuals would be less prominent. Tying the credits to income qualification limits might be politically advantageous and this would also be more efficiently done through the state income tax system.

States should also consider requiring that a tax credit recipient agree to be incorporated into an onsite system management district, a water district, or a watershed management district that has some power to mandate onsite system management activities. This would increase the likelihood the system would be properly operated and maintained, especially if it is an upgrade to an advanced onsite system. It would also encourage local authorities to establish such districts so that their constituents would have the opportunity to obtain tax credits. There is some precedent for tying funding to management in other funding programs. For instance, the

Community Septic Management Program in Massachusetts (see Section 2.1.1) requires that before communities can obtain funds they can lend to homeowners to address failing systems, they develop either a Community Inspection Plan that requires onsite system inspections every 7 years, or a Local Septic Management Plan that includes a data base for tracking inspections, requirements for routine maintenance, and prioritization of areas with systems that need more regular monitoring and maintenance.

Steps

This action requires legislation to establish the tax credit in the state income tax code. Advocates would need to identify sympathetic legislators to carry a bill forward. Legislators would be most sympathetic if the advocates were led by or substantially include one or more communities in their own district(s) that wish to improve onsite systems, and require financial assistance to individual property owners to do so.

Consulting engineers could play a key role in facilitating an approach to legislators. They could provide technical information on the need for onsite system replacements and upgrades in the advocate communities. They could also potentially arrange participation by state regulatory or financing agency personnel. Consulting engineers, particularly if they act through a state-wide professional society, have the relationships and may have the clout necessary to get buy-in to the idea from state agencies. One-person and other small engineering firms would be most likely to benefit from increased work resulting from creation of an onsite system tax credit (since most larger firms do not pursue individual residential projects), so they would be the most likely consulting engineers to be involved in a legislative effort.

Calculation of losses to state tax revenues as a result of the tax credit would be required. Consulting and state agency engineers could help make the case that the benefits of providing the credit are worth the cost to the state. Allowing the credit to sunset after some period of time, perhaps five to seven years, might increase the political palatability of the proposed legislation. The idea would be to provide a long enough subsidy period to “jump start” onsite system repair, replacement, and upgrade activity. A jump start period would make particular sense if the credit is connected to changes in onsite system regulations.

Implications

Other programs, such as those that address orphan stormwater systems[8], community water systems, and other watershed-based improvements, may see this idea as applicable to their interests as well.

Some system(s) would be necessary across different branches of government to ensure that tax credits applied for are actually linked to systems built. This should not represent a significant barrier but does need to be taken into account.

Measure of success

This action will have succeeded in each state when a tax credit is put in place and significant numbers of individuals in target areas use it to help fund rehabilitation and/or upgrades of their onsite systems.

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[8] An orphan stormwater system is one whose ownership and maintenance responsibility can not be determined.

2.2 Strategy: Require Consideration of Decentralized Options in Regulatory and Funding Processes

One way to give engineers an incentive to more equitably consider decentralized options is to require and enforce this consideration as part of the facility planning process or the funding process. Unfortunately, too often regulatory and funding requirements either do not require a thorough analysis of all options, or look the other way when engineers do only a cursory examination of decentralized options. Also, while NEPA technically requires a substantial alternatives analysis, it is rare that this examines decentralized solutions.

Regulatory and funding programs can require preparation of a facility plan that meets certain standards for consideration of decentralized options. Such requirements would establish a demand for consideration of decentralized options and generate billable work for consulting engineers, so they are more likely to supply the required consideration.

Other types of engineers may also benefit from these requirements. Manufacturer engineers benefit if increased consideration leads to increased sales of their products. Municipal engineers benefit if increased consideration leads to better community choices, thereby cutting system costs or increasing the benefits provided by wastewater systems.

2.2.1 Action: Require Serious Consideration of Decentralized Options in Facility Plans

Good wastewater system planning begins with a needs assessment aimed at determining whether current and planned wastewater systems in an area are adequate for current and expected sources of wastewater relative to regulatory requirements that are based on public and environmental health. If the needs assessment finds that some change to the current course is necessary, the next step should be thorough identification and analysis of a full range of options to provide wastewater services as part of the facility planning process.

Engineers engaged to develop a facilities plan often give only cursory attention to decentralized options. Many plans dismiss onsite or cluster systems by asserting, without analysis and often without documentation, that they fail to meet environmental goals, are too expensive, or are too hard to maintain (Pinkham et al., 2004).

Engineers and others in some regulatory and funding agencies have realized that too little is expected of consulting engineers who develop facility plans and submit them for agency consideration. Some regulatory and funding programs have instated stronger requirements for thorough alternatives analysis. The best of these explicitly state that decentralized options must be considered.

2.2.1.1 Facility Planning Requirements in New Mexico

Richard Rose, Chief of the Constructions Program Bureau in the New Mexico Environment Department, manages several state funding programs for wastewater systems, including the EPA-funded Clean Water State Revolving Fund (SRF). The Bureau requires applicants for all programs to submit Preliminary Engineering Reports (PERs). He has found that a key to inducing engineers to predictably write PERs that give equitable consideration to decentralized options is requiring use of a guideline that clearly states what is expected in the PER.

Rose uses the U.S. Department of Agriculture (USDA) Rural Utilities Service (RUS) Bulletin 1780 as the guideline. The RUS Bulletin contains many sections; RUS Bulletin 1780-3 is a seven-page document which describes the requirements for a PER related to wastewater projects funded by RUS (Rural Utilities Service). The bulletin cautions, "Documentation of alternatives considered is often a PER weakness," and specifies that the "following alternatives should be considered, if practicable: building new centralized facilities, optimizing the current facilities (no construction), interconnecting with other existing systems, and developing centrally managed small cluster or individual facilities." The bulletin also describes what is expected to be in the documentation for each alternative.

According to Rose, the specifications in RUS Bulletin 1780-3 have helped improve the quality of analysis of decentralized options in PERs prepared in New Mexico. Rather than dismissing decentralized alternatives in a sentence or two, most engineers are giving the alternatives real analysis. Getting to this point has required some pushing on the part of the Bureau. The Bureau has proved it is serious about the requirements by rejecting some PERs on the basis that the alternatives analysis was insufficient. In other cases it has had extensive dialogue with engineers about what constitutes "sufficient." The most powerful tool Rose has to enforce the alternatives analysis requirements comes from communities putting into RFPs and contracts for engineering services a requirement that RUS 1780-3 be followed, a recommendation Rose makes to communities that approach the Bureau for funding. Rose can then point to this condition in an engineer's contract to initiate a discussion about how to satisfy the alternatives analysis requirements.

2.2.1.2 Minnesota's Approach

Minnesota also has taken a strong approach to requiring consideration of decentralized options. As part of the Wastewater and Storm Water Assistance program codified in Chapter 7077 of the Minnesota Rules, a facility plan for an area currently served by individual sewage treatment systems (ISTS) must include an alternatives analysis submitted on a form approved by the commissioner of the Minnesota Public Facilities Authority. The worksheet presents a "Corrective Action Alternative Selection Hierarchy" that emphasizes evaluating decentralized options before considering centralized ones (Minnesota Pollution Control Agency, 2005). The worksheet states:

> This worksheet is designed to document the corrective action alternative selection process for project applicants requesting SRF financial assistance for wastewater treatment facilities improvements in unsewered areas of Minnesota. It is part of a process to encourage project applicants to evaluate all wastewater treatment alternatives that are prudent and feasible. Proposals receiving public grants or loans should be appropriately sized and provide a cost-effective solution to existing or anticipated water-quality problems. … The selected wastewater treatment alternative in an unsewered area should be based on an evaluation of possible alternatives, in order, from the hierarchy listed below. Note that different treatment alternatives may be combined within one project service area.
>
> Corrective Action Alternative Selection Hierarchy:
>
> - Replace existing failed ISTS with new ISTS on each lot with centralized management to provide monitoring, operation, maintenance and replacement.

- ♦ Combine properties with failed ISTS into decentralized multi-household soil-based wastewater treatment systems with centralized management to provide monitoring, operation, maintenance and replacement.
- ♦ Combine strategies including replacement ISTS, decentralized water system(s) and/or sewering to a centralized wastewater treatment facility with centralized management to deal with properties with failed ISTS.
- ♦ Connect the properties with failed ISTS to an existing wastewater treatment facility with available capacity and centralized management. Connect the properties with failed ISTS to an existing wastewater treatment facility with centralized management that requires additional capacity through an expansion.
- ♦ Develop a new wastewater collection and treatment facility with centralized management. Then connect households with failed ISTS to the new system.

The form required to document the corrective action alternative process addresses this hierarchy with a series of questions. It begins with a question corresponding to the first option in the hierarchy: “At which failed or nonconforming ISTS sites will new ISTS replacements be used as the corrective action alternative with centralized management to provide monitoring, operation, maintenance and replacement?” The next question requires justification for not selecting the preferred option: “Explain why all of the locations remaining in the service area are not suitable for this corrective action method.” Each option in the hierarchy is addressed with similar questions.

The Minnesota Chapter 7077 facility plan requirements specifically mention a goal of providing a cost-effective solution. RUS Bulletin 1780-3, discussed earlier, states “Present worth (life cycle) cost analysis (an engineering economics technique to evaluate present and future costs for comparison of alternatives) should be completed to compare the feasible alternatives. All of the items from the cost estimate should be included in the analysis.”

2.2.1.3 Additional Considerations

Many other facility planning guidelines mention cost analysis and cost effectiveness, but few provide guidance on how to determine cost effectiveness. A useful approach is true LCC analysis (including all costs) in the facility planning process. This may require substantial revision to current guidelines. For instance, planning periods greater than 20 years should be required. Twenty years is insufficient to capture, for instance, gravity sewer maintenance costs and costs of increased flow due to infiltration, both of which tend to be very low for 20 to 25 years but often increase after that. A 20-year planning period also does not capture costs associated with rehabilitation or replacement of key components of either centralized or decentralized systems. Forty years is a good planning period; it is long enough to capture most of the costs just noted. Planning period longer that 40 years may capture additional costs, but the discounted value (present value) of these costs is usually small and thus does not typically change the results. Guidelines should also require that all costs of each option be included, and may need to specifically list a range of potential cost items that should be considered. Often, costs such as trench dewatering, road repair after trenching, and biosolids disposal are left out of cost analyses. Energy costs also often are inadequately considered.

The effects of requiring serious consideration of decentralized options in facility plans include, obviously, more pressure on engineers to seriously do so, from regulators, clients, funders and the requirements themselves. This would likely eliminate some poorly conceived centralized plans, and will lead to engineers learning more about decentralized systems. Over time, this increased understanding should increase the likelihood that engineers will equitably consider and use decentralized options. This will increase engineers' financial reward for using decentralized systems, particularly in situations where centralized systems stand little chance of being affordable or funded. As one interviewee for this study said, "a small fee is better than no fee."

To the extent that engineers continue to receive greater financial rewards for using centralized systems, however, this action is insufficient. For maximum effectiveness, this action should occur along with the actions associated with the previous strategy (Section 2.1) on increasing funding availability. Consulting engineers will be most receptive to greater consideration of decentralized options if, along with a requirement to consider these options, they and their clients are also rewarded with a greater chance to get decentralized options funded. If decentralized approaches cannot be funded under a state's SRF, engineers are unlikely to give the approach equitable consideration even if facility planning requirements specify that decentralized options be included.

An adjunct action worthy of consideration is establishment of outside, professional advisory panels to assist permit writers and funding agency personnel with independent evaluation of the quality of the options analysis in facility plans. Regulatory and funding agency personnel, including engineers, sometimes have limited knowledge of decentralized technologies. An independent review panel could be used to determine if the options analysis in a submitted plan is complete and thorough. It could also help agencies determine if the life-cycle cost analysis used to determine cost-effectiveness of each option is reasonably comprehensive. This function would also be useful under Section 2.1.1 on funding review and ranking criteria.

Steps

This action probably needs to begin outside of the regulatory agencies, because regulatory agency personnel are too overworked to take on the effort or to champion changes that potentially add additional work in reviewing and enforcing implementation of the requirements. The action could start within funding agencies, as it did in New Mexico. The funding agencies have a more direct obligation than do regulators to ensure that wastewater systems are as cost effective as possible. Increasing cost effectiveness should stretch funding dollars further, helping funders fulfill their mandates.

In any case, the proper arguments for change must be prepared by the advocates of change. The arguments and how they are presented will depend on whether the changes can be made in agency guidelines or require more formal rule-making or statutory changes. The advocates must then work with the leadership of the pertinent agencies, and possibly with their legal staff and with sympathetic legislators, to promulgate guidelines or rules or to draft legislation.

The New Mexico example demonstrates that simply having analysis requirements is not enough; regulatory and funding agencies must enforce the requirements. Engineers in these agencies would be best situated to hold consulting engineers to the guidelines, as they would be most likely to be considered credible critics of insufficient alternatives analyses. Ideally, consulting engineers should be held to the requirements by contract as well. Agencies should encourage communities to include adherence to the guidelines as a condition in RFPs and contracts, as is done in New Mexico. Another approach, used in Broad Top Township and Coaldale Borough, Pennsylvania, is to include requirements in RFPs for engineers to design systems that meet specific criteria for affordability and analysis of innovative alternatives (Pinkham et al., 2004).

Implications

One of the most apparent effects of increased consideration of decentralized systems in facility planning will be impacts on groundwater programs. The recharge from decentralized systems will be viewed as a positive effect, while potential concerns include treatment standards, reliability, and emerging concerns about viruses and pharmaceuticals. Drinking water and stormwater programs will likely enter the discussion of facility plans over time if decentralized options are truly considered, as discussed in Chapter 5.0. Issues such as water re-use, low impact design, groundwater recharge opportunity, and cross watershed transport may enhance the overall economic and environmental assessment of decentralized proposals.

As overall ability to truly evaluate options grows, issues such as air quality and climate change could also become factors. For example, centralized plants require significant energy to operate. In most of the country, this energy is generated by fossil fuels, with negative effects on air quality and climate. Assigning a benefit to the evaluation of options for air quality benefits could easily result from such thinking, particularly if a state was out of compliance with air quality standards or was developing a greenhouse gas reduction strategy.

Broadening the requirements of facility plans may necessitate that funding for these efforts be increased. If engineers are to fully address decentralized options, the time and effort necessary to perform an alternatives analysis will often be greater. On the other hand, such a change should result in some facility plans resulting in lower cost solutions. Overall, one might expect greater time and cost for initial planning and engineering activities and lower costs for construction.

Success with this action may result in the need to evaluate the organizational structure of the involved regulatory agencies. Often, the regulatory arms that oversee centralized and decentralized systems are not within the same department and seldom work together. Additionally, the funding agency may not be co-located with and may not communicate with the regulatory arms. For example, decentralized regulatory programs and personnel are sometimes located in public health departments, environmental departments, or natural resources departments, while the finance mechanism could be in an environmental, public health, or administration entity. Though it may be a positive unintended consequence, requiring serious consideration of decentralized options in the facility planning process will likely require the organization of the regulatory and financial reviewers of facility plans to be modified.

Measure of Success

This action will have succeeded in a state when most advocates of decentralized systems in that state agree that the state has adequate provisions in facility planning requirements, and that these requirements are enforced such that most facility plans provide serious and equitable consideration to decentralized options.

2.3 Strategy: Increase Public Awareness and Address Misperceptions Around Decentralized Systems

It is helpful if key non-engineer stakeholders are adequately knowledgeable about decentralized options. Knowledgeable stakeholders are more likely to generate demand for decentralized solutions or to support those solutions when they are proposed. Increased demand and support results in increased financial rewards for engineers who provide alternatives analysis and design services for decentralized wastewater options. Creating this awareness requires correction of misperceptions about decentralized systems to remove dampers on demand, and education on the benefits of decentralized systems.

Two key stakeholder groups are environmental advocacy groups and local government officials. Environmentalists and the organizations that represent them have often been opponents of the decentralized approach to wastewater service provision. They often see decentralized wastewater systems as a direct threat to water quality compared to centralized systems, and they may see decentralized systems as an indirect threat to their goals, believing they facilitate sprawl patterns of growth. Yet it is possible to turn environmentalists from potential opponents of the decentralized approach into proponents on environmental grounds. Engaging environmental groups is discussed in detail in Section 4.2.1.

Local government officials are usually not aware of the variety of wastewater technology choices potentially available to their communities. Few have a sense that a decentralized approach with management can be less costly than a centralized one. Since local government officials are ultimately accountable for a community's wastewater system decisions, the action below addresses how they can be engaged and educated. The potential financial aspects of decentralized systems are perhaps the best means to gain their attention. This education can be situation-specific, and delivered through consulting engineers in their relationships with particular municipal clients, by other consulting engineers in their proposals for competed work, and by regulatory and funding agency personnel. The education can also be more general, and delivered through various efforts to reach local officials aside from specific wastewater planning efforts.

2.3.1 Action: Educate Local Government Officials on the Financial Advantages of Decentralized Systems

The alternatives analysis phase of the facilities planning process, as discussed in Section 2.2, is an opportunity to educate local government officials and the general public about the range of options relevant to their community and the costs of each alternative. Focusing the educational effort on the financial benefits of decentralized systems is a particularly powerful way to increase interest in decentralized options. This interest will often translate to increased demand for and support of decentralized option analysis. This demand and support, in turn, increases engineers' financial rewards for considering and using decentralized systems.

As a starting point for this educational effort, it is important that alternatives be analyzed through a sufficiently broad life-cycle cost analysis. One resource for such an analysis is a "catalog" prepared for the U.S. EPA (Pinkham, Hurley et al., 2004) of the costs and benefits of decentralized options—many not commonly understood—relative to more centralized options. Consulting engineers and municipal engineers who work on facility plans should make a concerted effort to educate local decision makers and opinion leaders about the technological options and their full range of costs, benefits, and management requirements.

Most often, the fundamental economics of a community's wastewater choices will be driven by trade-offs between economies of scale in treatment system capital and operating costs and diseconomies of scale in collection system costs. Local government officials will be keenly interested if a decentralized system offers lower net capital and operating costs than another alternative. Additional considerations may also catch their interest, including financing costs (the cost of borrowing money to build a system) and the financial risks attendant to infrastructure investments.

Work by Pinkham et al. (2004, "Smallside" analysis) has shown how a decentralized approach has a lower financing cost than a centralized system with the same ultimate capacity and the same net present value of construction and O&M costs. A decentralized system has a "just in time" capital cost pattern compared to a centralized system that is underutilized until growth catches up with overbuilt capacity necessitated by the "lumpy" nature of constructing centralized system capacity. A decentralized approach often requires less upfront borrowing, so financing costs are spread further into the future, reducing their effective cost to today's decision makers.

A decentralized approach also carries less financial risk if expected growth does not materialize. Decentralized options allow anticipated but not-yet-built capacity to be cancelled, while a past investment in centralized capacity to accommodate growth cannot be undone, leaving fewer rate-payers to foot the bill. This aspect of the decentralized approach helps communities avoid pressure to generate growth or extend sewers to capture more revenue to help pay off a centralized system.[9]

Steps

The discussion above on facility planning indicates how efforts to educate local officials can be focused on the economic and financial aspects of wastewater system decision. Targeting officials who are responsible for the financial implications of a decision—depending on the community, town board members, city council members, mayor—is especially powerful. These local officials with the power and responsibility of the purse are most likely to take in and utilize appropriate information. And they are the stakeholders in the best position, once they understand the implications, to support demand for engineers to consider and use decentralized systems. Several complimentary approaches can also be used:

- Other, non-financial information generated by consulting engineers in the facility planning process can be used in the education process. The consulting engineer should bear some responsibility to adequately present this information and educate decision makers about the financial and other pros and cons of each alternative. However, success in this effort may require that the engineers' relations to the community are sufficiently strong.
- Where communities have municipal engineers, these engineers can serve as an important conduit between consulting engineers and local decision makers. In some cases, however,

[9] It may also be helpful to establish a wastewater district that allows management fees to be levied to capture revenues from onsite systems, assuming those fees can be used across an integrated centralized and decentralized municipal wastewater department or utility, and the costs of management do not exceed the fees.

the municipal engineers will themselves need to be educated by consulting engineers who know decentralized systems well.

- State and federal agency engineers who have regulatory or funding roles can help educate local officials and municipal engineers through the regulatory and funding processes. Service provider engineers (e.g., those with the Rural Community Assistance Corporation) can play a similar role. The educational process can take place around community-specific issues and analyses, or engineers can provide case studies and contacts to other communities that have had success with a decentralized approach.

A possible model for local official education is EPA's stormwater Phase II program. Significant outreach to engage local decision-makers in creating awareness of distributed infrastructure has occurred through the Phase II effort.

Broader educational efforts not oriented to specific infrastructure decisions may also be useful. For instance, it would be helpful to build general awareness among local government officials of the potential financial advantages of the decentralized approach, so they will be thinking along those lines before they embark on a needs assessment or facility planning process. There are many possible venues for broader educational efforts:

- Local councils of governments (COGs). In particular, in some states COGs are responsible for Clean Water Act Section 208 basin water quality plans. The 208 process may provide an opening for COG staff and engineering consultants to the COGs to present and discuss the decentralized approach with local officials.
- State agencies concerned with good local governance. In many states, the Secretary of State's office educates local officials about the laws, regulations, and policies they must comply with. Consulting, municipal, and agency engineers, perhaps acting through a statewide professional society, could offer their services to the Secretary of State in bolstering efforts to educate local officials with respect to their financial and regulatory responsibilities around wastewater infrastructure and system management.
- State associations of local officials. Almost every state has a "League of Cities and Towns." These organizations represent municipal government interests before state legislative bodies, the state executive, and administrative agencies. They also provide information, technical assistance, and training to municipal officials.[10] Conferences and periodicals of these organizations could be used to help educate local officials about the potential financial benefits of decentralized systems.
- National associations of local officials. These organizations include the National League of Cities, the U.S. Conference of Mayors, and the International City/County Management Association (ICMA). Conferences and periodicals of these organizations could be used to help educate local officials about the potential financial benefits of decentralized systems.

Implications

Educational efforts should be integrated with other initiatives to educate local government officials, to avoid overloading them with too much information.

There is the potential of additional costs to communities on the front end associated with education efforts, but these costs are likely to be repaid many times over as less expensive

[10] http://www.rileague.org/site/about/index.html

projects are constructed. The new costs could be shared across private, non-profit, and governmental sectors and may not represent a significant cost to any individual sector.

When regulatory programs work their best, there is an element of education occurring between permit applicant, community, and regulator. This learning occurs in all directions. If government's role in education is substantial, some planning will be required as to how best to implement this role.

Measure of Success

This action will have succeeded when most local officials who are facing wastewater system decisions support consideration of decentralized options. This support might be demonstrated in applications for planning grants or other planning assistance that specifically include mention of considering decentralized options. Funding and regulatory agency officials may also be well positioned to judge whether most local officials they deal with are receptive to the decentralized approach, or to request their engineers to consider this approach.

2.4 Strategy: Adopt New Business Models for Engineering Firm Success with Decentralized Systems

For many years, few engineering firms gave much attention to decentralized systems. Many firms apparently did not consider decentralized projects significant enough to be worth going after, or the options attractive enough to their clients to be worth seriously considering. This view appears to be changing, particularly for small and medium-sized firms. A number of these firms are finding that communities, developers, and other clients need decentralized solutions, and are finding ways to attract, capture, and profit from this work. They have developed innovative marketing strategies to find the clients necessary to generate revenues from expertise in decentralized technologies and management. The first solution below highlights several firms whose successful business models leverage expertise in decentralized systems.

The second solution addresses a barrier commonly mentioned during interviews for this study. Many interviewees emphasized that the fees earned by consulting engineers are smaller for decentralized options, since these options are smaller and often less costly than centralized options. Therefore, engineers have little incentive to seek out decentralized wastewater jobs or to seriously consider using decentralized options (Rhonda Shippee, Business Program Director, USDA-Rural Development, Vermont, personal communication). This barrier invites the larger question, "how do engineers get compensated, and are there other ways they could be compensated that might make decentralized options of greater interest?" The answer is "yes." As shown below, innovative business models based on alternative compensation are available.

2.4.1 Action: Implement Alternative Marketing Strategies

One approach to success with decentralized systems is for an engineering firm to include decentralized systems as a key part of its market strategy. This may include using decentralized wastewater expertise as a service that helps capture additional business from existing clients, or including decentralized wastewater services as part of an overall marketing strategy.

NorthStar Engineering is an example of a firm that sees decentralized system expertise as both a service to clients and a tool that generates additional business (see case study in Section 1.2.2). The firm successfully provides wastewater solutions to developers in unsewered areas of northern California. NorthStar provides site development engineering services including surveying, building design and structural engineering, and onsite wastewater design. The latter provides 10 to 15 percent of total revenues but has the benefit of generating "job creep" into the firm's other services. Clients hire the firm to do surveys, map approvals, and other work because they recognize it has the expertise and regulatory relationships to get permits for the decentralized wastewater systems that are essential to the clients' development projects.

Nolte Associates is a consulting engineering firm with several hundred employees and 12 offices in California, Colorado, and Utah, plus two offices in Mexico. The firm offers planning, surveying, engineering (structural, water and wastewater, and transportation), and construction and program management services. Nolte Associates has made sustainability one of its core marketing strategies (George Nolte, President, Nolte Associates, personal communication). This strategy has helped the firm win numerous contracts for civil engineering services for large, master-planned developments of 1,000 to 5,000 acres, water-related infrastructure planning for a large new university campus, and other significant jobs. The firm emphasizes sustainability in its marketing materials and in the training of its engineers. The firm has a web-based sustainability course on its intranet and produced a 30-page executive summary booklet, "Applying Sustainability Principles in Nolte's Engineering Practices." The objective of these education tools is to get the principles "inside the mind of the design engineer," according to George Nolte, the firm's president.

George Nolte sees decentralized wastewater system planning and engineering as a key component of a sustainable strategy and as part of providing the right infrastructure solutions for clients. He quotes Harry Truman, who said "any engineer can design a bridge; a good one will tell me if it's needed or not," to emphasize that a good engineering firm provides more than just design "production work". The client, notes Nolte, says "I need infrastructure," and it is then the role of the engineer to provide the best options. Frequently this requires educating the client about unfamiliar options such as decentralized wastewater technologies. Nolte Associates also supported the decentralized wastewater field by sponsoring development of the preeminent textbook in the field, *Small and Decentralized Wastewater Management Systems* (Crites and Tchobanoglous, 1998).

Another firm that emphasizes decentralized wastewater services and sustainability as part of its marketing is North American Wetland Engineering (NAWE). This firm is profiled under the next action on implementation of alternative business models (Section 2.4.2).

Steps

This action depends on individual consulting engineers and consulting engineering firms taking the initiative to consider and adopt alternative marketing strategies. Promoting engineering services for decentralized systems will not work for all engineers and firms.

Those firms considering this approach must carefully define the marketing strategy of interest—a niche market strategy, an appeal to sustainability, or another approach—and evaluate the strategy against a variety of factors. These include the potential market in their region, the state and likely evolution of competition relative to the service offerings being marketed, their own resources and ability to market their services, and their tolerance for any risks that the marketing strategy might not work.

There are some further general actions that engineers interested in this action can do. One is to “spread the word” about alternative marketing strategies in venues such as professional engineering societies. Presentations at society meetings by successful engineers would help open the eyes of others. Articles in society periodicals or other engineering industry periodicals would do the same, perhaps in the form of profiles of engineers or firms that are using alternative marketing strategies. University engineers could also include presentations by or profiles of successful engineers in their syllabi, to let students know there are multiple approaches to business success. In all these efforts, the focus would be on the engineers or firms and how they have become successful businesses, rather than the traditional focus on specific projects.

Implications

By promoting themselves across a wide spectrum of water-based services, consulting engineers will enhance the work of all water-based programs by helping prospective clients see and understand the business benefits of more integrated approaches. This should have positive consequences for governmental water-based programs in their work with developers and other constituencies.

Measure of Success

This action will have succeeded when multiple firms in each state and region market decentralized system expertise as a key service offering.

2.4.2 Action: Implement Alternative Ways to Compensate Engineers for Recommending Decentralized Systems

Engineers typically earn revenue by billing hours, serving clients under a “design–bid–build” model (DBB) (Balas, 2006; Christopher and Rohrer, 2005). They bill a client for time to select and design a wastewater system, help the client obtain and evaluate bids from construction contractors, and then supervise construction for the client. To the extent that decentralized systems require less engineering time, engineering firms obtain less revenue from them, and therefore may be less inclined to consider and recommend them. However, while decentralized treatment systems may be simpler to engineer and construct, they require other work, such as soils surveys, that can generate revenue for engineering firms with the requisite expertise.

A variation on the DBB model that is currently increasing in popularity is the “design–build” model (DB) (Balas, 2006). In this approach, the engineer and contractor collaborate closely, sometimes as a single firm, to optimize design and construction. The DB model often produces cost savings and reduced implementation time for the owner. Among the efficiencies are the elimination of the construction bidding and procurement process. The DB model can provide benefits to both centralized and decentralized facilities.

Engineering firms essentially sell time in both the DBB and DB models, and these are the most common ways for engineers to be compensated for wastewater projects. However, there are three major alternatives to selling time related to design and construction:

- Obtain compensation from sale of a product
- Obtain compensation from ongoing costs after construction (O&M and management)
- Obtain compensation from a return on equity invested in owning a system

Engineers can take advantage of any of these compensation strategies by changing or expanding their business model. The three additional models are discussed below, both in concept and with examples from the decentralized wastewater field.

2.4.2.1 Obtain Compensation from Sale of a Product

Obtaining compensation from the sale of a product is often called the vendor designer model. Typically, an engineer partners with one or more manufacturers. Based on knowledge of their systems and contract agreements, the engineer charges a reduced fee for designing the installation of a particular wastewater technology for a property owner, but receives additional compensation from the manufacturer for selling the product. This is a relatively common and viable business model used particularly by individual engineers but also by some multi-engineer firms. The vendor designer model is also used by many non-engineer designers. It provides a client with efficiencies with respect to a particular technology, but it may not match a client's needs as well as an engineer who is free to recommend or use any type of technology.

2.4.2.2 Obtain Compensation from Ongoing Costs after Construction

Another potential source of revenue is the stream of payments that should occur over time for operation, maintenance, and management of decentralized systems. The need for proper management of decentralized systems is increasingly understood and accepted, and is increasingly mandated by regulatory authorities, local governments, and even manufacturers. This creates a stream of payments that can be viewed as revenue by operators or managers of small systems. Engineers may be well-situated to provide or organize the appropriate expertise, particularly for more advanced systems. Advanced onsite systems sometimes require both monitoring data and annual inspection reports by engineers.

A common model that takes advantage of ongoing payments is the design–build–operate (DBO) model. In this model, expertise on design, construction, and operations is pulled together by one firm or by a team of multiple firms. Besides the attractiveness to the successful firm(s) of capturing ongoing revenues, this model can provide benefits to the purchasing entity such as those identified by Christopher and Rohrer (2005):

- The consulting engineer can work more closely with a technology manufacturer due to the more confidential nature of the DBO process as compared to the DBB model. This helps optimize technologies.
- Significant schedule efficiencies can be realized by using the DBO approach, by eliminating several stages of the normal agency design review process. Further, due to the integrated involvement of the contractor and equipment manufacturer in the design, it is likely that construction will be completed more rapidly.
- The DBO approach puts the responsibility for O&M directly on those most familiar with a technology/design and its nuances.
- All construction and O&M costs are included in the DBO proposal packages, facilitating lifecycle cost analysis and guaranteeing capital, O&M, and repair and replacement costs.

In exchange for generating these benefits for the client, the DBO firm or team is guaranteed ongoing revenues for operating, maintaining, and managing the system(s). It should be noted that both manufacturer and consulting engineers can benefit. Advanced technologies and changing regulatory requirements are creating O&M and monitoring gaps that can be filled by the manufacturer engineers, consulting engineers, or combinations of both. Manufacturer engineers can work in partnership with consulting engineers during the planning, design, construction, and O&M phases. Technology companies like Orenco and Aquapoint are expanding their involvement in all of these areas. Some are requiring specific training and certification on their systems for designers, installers, and service providers. Some are developing data management systems to track O&M activities and report to regulators. Premier Tech includes annual O&M inspections and peat replacement in their purchase price and requires continuous service agreements from the homeowners.

NAWE is a consulting engineering firm that has utilized aspects of both the vendor designer model and the DBO model. NAWE is located in White Bear Lake, Minnesota, not far from Minneapolis. The firm currently has 23 employees, including 12 engineers and 7 technical staff with various science degrees. NAWE has designed over 250 decentralized wastewater systems across the country. The firm is especially known for expertise in constructed wetland treatment systems, but also utilizes other types of treatment systems.

In recent years, NAWE principals have established two additional companies (Curt Sparks, President, North American Wetland Engineering, personal communication). One is EcoCheck, Inc., which provides O&M and management services. The other is Reactor Dynamics, Inc., which makes and sells a proprietary treatment system for the single-family residential market. The three companies are owned by the same individuals, but in different proportions. Each is operated entirely independently, though workers in each have easy access to each other. Employees of each company bill the other companies for any “outside” work they do for them.

According to Curt Sparks, President of NAWE, Reactor Dynamics came about as the result of patents NAWE established for wetlands treatment technologies. These patents lent themselves to simple products to sell into the residential market. The result was the “DYNO2,” which is essentially a pre-built recirculating gravel filter enhanced with wetland plants, the root systems of which are aerated. About 100 of the units are now in service. For certain residential projects, the unit allows some design standardization, and the NAWE/Reactor Dynamics owners benefit from both the design services and the sale of the product.

Many NAWE-designed systems are larger and more complex. EcoCheck, he says, was “forced out of necessity” to ensure proper O&M of NAWE-designed systems. The problem, says Sparks, is that for advanced decentralized systems, one can be the best designer and supervise construction closely, but the systems will not work in a few years if they are not properly managed. Various developers asked NAWE for management services, and NAWE began to provide them. After about ten of those requests came in, NAWE decided it was time to look carefully at how to best provide the services. The answer was to set up EcoCheck as a separate company. The company started in 2002 and now operates 85 sites with current capacities of up to 60,000 GPD.

Sparks believes that most current business models for delivery of system management are not working. He points out that most of the larger community systems have been built. Most of the need now is for "crossroads" communities and similar unincorporated places of 100 or fewer homes, with little governmental structure. He thinks the expectation is illusory that these places can manage systems themselves or even that the township in which they are located can, when they struggle to organize themselves well enough to keep roads maintained. He sees a real need for companies like EcoCheck for O&M and management, both for communities (and private developments and homeowners' associations) and for the engineers to ensure their systems continue working.

Understanding and addressing liability is critical to success for engineering firms that work with decentralized systems. Liability insurers look at the number of systems a firm has installed—each is the firm's legacy, and carries potential liability risks. Sparks has been successful in negotiating good liability coverage rates. One thing that reassures both him and insurance companies is the utilization of EcoCheck services on projects. If a system has a fatal flaw, EcoCheck will find it in the course of their business, notify NAWE, and NAWE can negotiate a solution with the system owner.

Sparks believes it is important to keep companies with differing functions separate. This practice reduces financial risks and addresses potential issues for engineers with their code of professional ethics. As an engineer, he feels an obligation to fix anything that is "broken," even if the system is compliant. This typically results in higher capital costs. An operator, however, needs flexibility to run a system in the best way for the client, which may mean running a system in a way that is not optimally efficient. Such an approach may incur increased operating costs, but this option may be more agreeable to the system owner. Sparks notes that large engineering companies which have undertaken operations of large centralized facilities also form separate operating companies.

EcoCheck benefits from the steady revenue source provided by ongoing service payments, but the firm has had to become extremely efficient to succeed. EcoCheck accomplishes this by developing business along corridors and in concentrations, so that multiple sites can be worked on one service trip. The firm utilizes scheduling tools, prescribed task lists, PDAs (personal digital assistants) with activity check-offs and easy data uploading to automatically generate monitoring and maintenance reports, and other work-flow time savers. EcoCheck handles its current 85 sites with just three employees.

Sparks believes more engineering companies can and will offer similar services. The essential step is to thoroughly understand operations—which, he cautions, many consulting engineers do not. He benefited from previous experience in manufacturing, which is a different sector but one where similar principles of integrating multiple operational activities, each with its own efficiency curve, apply.

2.4.2.3 Obtain Compensation from a Return on Equity Invested in Owning a System

The third "alternative" compensation model is to obtain revenues based on an ownership interest in wastewater systems. The concept is sometimes called the design–build–own–operate model (DBOO). In this approach the firm or team that designs and builds the system(s) also puts up the capital for the system. They then charge customers fees that recover the capital costs plus a reasonable return on that capital, as well as recover the ongoing O&M costs. This model can be applied to individual decentralized systems (typically larger cluster systems) or to multiple systems, as a utility. DBOOs that are private entities are typically regulated by a state public utility commission, which sets allowable returns on capital.

One example of a decentralized wastewater systems utility is Tennessee Wastewater Systems, Inc., which grew out of an engineering company started by the Pickney brothers in the mid-1980s and now owns, operates, and manages cluster systems in a number of communities in that state (Stiles, 2004). Charles Pickney points out the importance of ownership: “If you’re in the role of the maintenance contractor, your job is only going to last as long as the owners want you to be there. At some point these owners may decide to cut costs by eliminating the maintenance contract and no one will hear from them until the day that they start having a problem with the system” (quoted in Wasson, 2006).

Ed Clerico, founder of Applied Water Management (AWM), is a P.E. who works extensively with the DBOO model and particularly with the private utility approach (Ed Clerico, founder, Applied Water Management, personal communication). AWM is now owned by American Water and has offices in six states that offer geoscience services as well as design, construction, and operation of decentralized water and wastewater systems, including systems under a utility ownership model. Clerico began as a designer of treatment systems for commercial and cluster residential applications. Many of his systems provided highly treated water for direct reuse for toilet flushing and other nonpotable uses and often involved membrane bioreactor style treatment systems. He found it difficult to find competent contractors to build the systems he designed because they were relatively small and complex. The onsite system contractors were mostly installers of simple septic systems, and the centralized wastewater plant construction contractors mainly were interested in large projects that involved poured concrete structures. AWM began using the design–build approach to ensure that the systems were properly constructed and to gain efficiency in the system delivery process.

Clerico soon found that DB was not enough. Towns were unwilling to take on operation or ownership of developer-funded systems, particularly if they utilized unfamiliar processes. He decided to fill this gap by developing AWM into a utility that offered the full range of DBOO services.

Clerico notes that in his experience, he and his firm morphed from being consulting engineers into something else pretty early on. His evolving business model always had a strong engineering component, but it was engineering along with other kinds of water resource related business.

DBOO is a complicated business model, according to Clerico. To be successful, one has to know four different businesses, each of which has a different behavior and risk/profit profile. A critical factor in AWM’s success was being able to obtain a single, statewide rate structure from the New Jersey Board of Public Utilities for the utility aspect of the business. This allowed AWM to spread costs, cost risk, and other risks across a portfolio of systems.

Clerico believes that this type of business model will increase in use, and will see innovations, in the decentralized wastewater sector more than in the centralized sector. This is because the decentralized sector does not have same entrenched practices and power structure that have, in Clerico’s view, quashed private sector participation in ownership of centralized systems. He traces this structure back to the construction grants program that only provided funding to public entities, and compares it to the greater level of private sector participation, and innovation, in the wastewater industry in Europe.

Private sector ownership is not the only approach to the DBOO and utility model. Public entities can also be owners of systems across local jurisdictions. One example of this is Newnan Utilities, the municipal utility company for the community of Newnan, in Coweta County, Georgia (Dietzmann, 2006). The county government provides centralized wastewater services to parts of the county, but decided it did not want to take responsibility for proper management of decentralized cluster systems. The county and Newnan Utilities have developed a cooperative agreement that establishes Newnan Utilities as the sole designer, builder, owner, and operator of cluster systems in the county. This ensures a uniform standard for technologies and management of decentralized cluster systems in the county. Such a model requires substantial participation from engineers, but within a public enterprise rather than private company framework.

Steps

This action depends on individual consulting engineers and consulting engineering firms taking the initiative to consider and adopt alternative business models, or on other types of businesses taking on the engineering aspect of full service project delivery. Only individual engineers and firms can determine what is right for them, or adapt business models to fit their own situation. Given the business background of most consulting engineering firms, it is more likely that innovation for the decentralized wastewater industry will come from the non-engineering sector where businesses are more comfortable with different management profiles. Water softening and water filtration are good examples that illustrate how product manufacturers and service companies can assume full service business models that include design, installation, and maintenance of equipment.

As with the previous action for adoption of alternative marketing strategies, engineers considering alternative business models must first educate themselves about the potential models. Then they must carefully define for themselves a model of greatest interest, and evaluate it against a variety of factors. These include the potential market in their region for the type of services a particular model would provide, the state and likely evolution of competition relative to the products or services being offered, their own resources and ability to undertake the new aspects of a new business model, and their tolerance for any risks that the model might not work.

As with alternative marketing strategies, engineers interested in alternative business models can take additional, more general steps. In particular, it would be helpful if more engineers knew about alternative business models for success with decentralized wastewater systems. Professional engineering societies provide a good venue for general educational efforts, including presentations at society meetings by engineers who have been successful with alternative models, and articles in society periodicals or other engineering industry literature.

University engineers could also include presentations by or profiles of engineers who use alternative models in their syllabi, to let students know that selling and billing design time is not the only path to success. In all these efforts, the focus would be on the engineers or firms using these models and how they have become successful businesses, rather than the traditional focus on specific projects.

Other non-engineering business types are unlikely to enter his market because it is highly fragmented and inconsistent. If there were one set of rules and product and service companies could readily envision a national business platform, the business environment would change and there would likely be more interest from larger companies.

Another general activity that might be necessary in some geographic areas is to identify and address regulations and policies that need to be changed for certain models to succeed. This could include changes to regulations on management and operation of decentralized wastewater systems. It might also include changes to state public utility commission rules and policies that affect how a DBOO utility can be run and how it makes its profits.

Implications

These business models should have crossover appeal for both stormwater and community water systems due to their common focus on decentralized, small, innovative solutions. Thus, it may be possible to widen the field to increase interest. It is possible that decentralized solutions to a variety of water management issues could become a suite of services that engineering firms could offer. New business models such as those described above could apply across the suite of services. There may also be existing business models from the distributed stormwater and small community water systems arenas that could be applied to decentralized wastewater systems.

This strategy is most likely to influence small to medium-size entrepreneurial firms. Large firms tend to require larger overhead multipliers and thus larger projects and profits to stay profitable.

The engineering of decentralized systems sometimes take a larger percentage of the overall capital budget, with more cost to develop the concept and less on the construction oversight end. A great deal of client education may be needed to address the likely reality that engineering and inspection costs for decentralized projects will represent a higher percentage of total cost than decision makers are familiar with in dealing with centralized solutions. Focus instead will need to move to total project costs and total engineering and inspection costs. For this model to work, engineers of all types must assist in the creation of clients with interest in utilizing decentralized infrastructure. Small and medium engineering firms will migrate to its use if this infrastructure can be shown to be less expensive, easy to permit, and acceptable to clients.

Regulators will need to be open to new approaches by engineers for different business models to work. For example, in managing current funding programs, regulators often rely on an acceptable range of engineering and construction oversight costs in reviewing the appropriateness of a funding application. These ranges have typically been developed based upon past experiences of reasonable fees for these services and are thus based on centralized solutions. Further, regulators have a key role in helping engineers find clients willing to try this infrastructure through the tone they set in discussions with developers regarding the permit process, and with municipalities planning on new or expanding services.

Measure of Success

This action will have succeeded when multiple firms or public entities in each state and region use one or more of the alternative compensation business models described above.

CHAPTER 3.0

INCREASING ENGINEERS' KNOWLEDGE OF DECENTRALIZED SYSTEMS

A majority of engineering students complete their undergraduate studies without being exposed to the concepts and technologies of soil-based treatment or decentralized systems and do not need to understand these systems in order to pass their licensing exam (see Section 1.3.2). For engineers who nonetheless find work involving decentralized systems, it becomes apparent that the centralized field has been the subject of more thorough research on its technical and organizational needs. Knowledge of how decentralized wastewater systems work gives engineers power to give the systems equitable consideration. When engineers know how to design and evaluate decentralized systems, they can consider how closely such systems might match a community's needs.

This chapter contains recommendations for overcoming knowledge barriers through increasing training and research opportunities. The previous chapter discussed difficulties that engineering firms encounter when including decentralized wastewater treatment in their business model. The firms also incur greater costs when, as is often the case, they need to train newly hired engineers on decentralized systems. Business experience demonstrates that advanced training is necessary to excel in the decentralized field. For example, engineer Chuck Johnson devoted years of his career to decentralized design before he completed a master's degree with an emphasis on decentralized systems (see Section 1.3.4). Completing his graduate studies allowed Johnson to design more creatively and to sell his designs more authoritatively. Despite this, few universities currently offer an advanced degree in decentralized wastewater engineering.

Additional basic research on soil-based systems and decentralized technology is also needed to advance the science of decentralized wastewater treatment. The past decade has seen tremendous advances in technologies and understanding of soil treatment, which allow decentralized systems to be safely installed in areas that never would have been feasible in the past. While many important projects still await funding, one possible project can significantly contribute to engineers' ability to equitably consider decentralized treatment options: research on the reliability of decentralized technologies and their components, which would significantly advance engineers' ability to make equitable design decisions and cost comparisons.

3.1 Strategy: Increase Teaching of Decentralized Systems

Most engineers learn the first formal knowledge of their craft at universities. When engineers obtain civil and environmental engineering degrees with little classroom instruction in decentralized wastewater treatment (see Section 1.3.4), they are poorly equipped even to ask the right questions about decentralized alternatives.

Faculty members who teach decentralized wastewater treatment at six universities were interviewed about their experiences and their knowledge of other programs.[11] They agree that decentralized systems and technology are not normally taught in engineering programs, with upper estimates of fifteen universities that teach a course devoted to decentralized wastewater treatment. At those universities, the courses are often in the agricultural engineering or public health engineering programs, not civil or environmental engineering. Thus, the majority of environmental engineering students are not exposed to the concepts and technologies of soil-based treatment or decentralized systems.

Changes made at the university level have the potential to influence many areas of society. The roles that different types of engineers can play in influencing universities are described for each action in this section. Engineering students can receive at least two hours of instruction on decentralized wastewater treatment systems. For engineers already in practice, continuing education courses are a way to acquire more knowledge of decentralized systems. Increased funding of university research on decentralized systems is likely also to improve the teaching of decentralized systems. Research projects often drive the subjects that faculty members teach, the teachers' depth of knowledge of the subjects, and the availability of graduate programs. Finally, developing decentralized-related questions for the professional engineer exam drives P.E.-candidate studies and could affect curriculum.

3.1.1 Action: Universities Teach Engineering Students a Minimum of Two Classroom Hours in Soil-Based Treatment and Decentralized Technologies

Since most engineers graduate with no undergraduate studies of decentralized technologies, any classroom exposure at all is an improvement. Kitt Farrell-Poe (personal communication), who teaches decentralized wastewater treatment at the University of Arizona and chairs the Consortium of Institutes for Decentralized Wastewater Treatment ("Onsite Consortium"), believes that two hours of classroom instruction is the minimum to introduce soil-based treatment and decentralized technologies. Peggy Minnis (personal communication), who teaches decentralized wastewater treatment at Pace University and has co-authored a textbook in the field, suggests three hours: one week of class time in a course that meets three times a week. If all civil and environmental engineering students receive a short introduction, they will be better equipped to recognize decentralized treatment as a potentially useful alternative and to learn more about it.

According to Farrell-Poe, several existing, standard courses offer opportunities to introduce decentralized treatment. An introductory environmental engineering course attracts upper-level undergraduates and graduate students, and it could include two lectures on decentralized systems. An introductory course on wastewater treatment could incorporate two similar lectures. A senior seminar on topics in environmental engineering also offers opportunities to bring in a guest lecturer on decentralized treatment.

John Buchanan (personal communication) of the University of Tennessee is invited to guest lecture to over 100 civil engineering students each year as part of the university's undergraduate course in water and wastewater. Buchanan uses two lectures to explain how the

[11] John Buchanan, University of Tennessee; Jim Converse, University of Wisconsin–Madison; Kitt Farrell-Poe, University of Arizona; Mark Gross, University of Arkansas (formerly); Dave Gustafson, University of Minnesota; Bruce Lesikar, Texas A&M; Peggy Minnis, Pace University.

unit processes studied (e.g., activated sludge) are scaled down and used in decentralized treatment, and that the effluent is usually discharged to soil afterwards.

Introductory textbooks for wastewater treatment and environmental engineering emphasize centralized processes, says Farrell-Poe. The Onsite Consortium developed an academic curriculum for decentralized wastewater treatment that is available at no cost (www.onsiteconsortium.org). Since the curriculum is for a one-semester course, it would require considerable time and expertise to select the best material for a short introduction. Textbooks for one-semester courses in decentralized systems (e.g., Burks and Minnis, 1994; Crites and Tchobanoglous, 1998) are similarly difficult to excerpt.

Several actions would make it easier for university engineering instructors to give their students an introduction to decentralized systems and concepts:

- The Onsite Consortium could develop short introductions to decentralized concepts for upper-level undergraduate engineers. The introductions would contain both reading material and slide presentations. One-lecture, two-lecture, and three-lecture variations would give instructors flexibility in how much classroom time they use for the topic.
- Authors of wastewater textbooks could incorporate decentralized examples and information in their discussions of wastewater constituents and processes. Also, they could include a chapter on the spectrum of collection and treatment system architecture, from onsite systems to large centralized systems.

A semester-long course offers a more robust opportunity for an engineering student to understand the principles, advantages, and limitations of decentralized technologies, as well as how the technologies can be integrated with centralized systems. Currently, there are estimated to be no more than fifteen universities that offer such a course.

Steps

While increasing the number of universities that teach a semester-long course in decentralized systems would give more graduating engineers the opportunity to obtain advanced knowledge of decentralized systems, it is unclear how to move directly from a university with no decentralized teaching to a one-semester course with a significant number of students enrolled. The actions described below are likely to make the transition easier:

- Increasing funding for decentralized research at universities (Section 3.1.3); and
- Developing decentralized questions for the professional engineer exam (Section 3.1.4).

University courses and guest lectures in other courses are developed through the efforts of faculty "champions" (Mark Gross and John Buchanan, personal communications). A faculty member offers to teach a course, and then he or she is responsible for recruiting students to it. It appears as a "special topic" course at first. If it attracts enough students to be offered multiple times, it is assigned a number and appears in the catalog. Similarly, John Buchanan said his guest lectures in the unit processes course came about through him making himself available to the colleague teaching the course.

Materials are publicly available to teach semester-long courses on decentralized wastewater treatment. However, university faculty interviewed report that shorter introductions are not readily available. It would be useful for the Onsite Consortium, textbook authors, and university engineers now guest lecturing in decentralized treatment to publish materials for one- to three-lecture introductions for civil engineering courses.

When the materials are available, it is ultimately up to qualified engineers on the university faculty to teach a course or a module. Other useful actions by engineers include:

- ♦ Consulting engineers work through their university alumni associations to encourage that the universities teach a course or module on decentralized treatment.
- ♦ Consulting engineers or qualified engineers in any other part of the field contact engineering faculty members and offer to provide guest lectures on decentralized systems. Appropriate engineering courses include unit processes, introduction to environmental engineering, wastewater treatment, and special topics seminars.

Implications

None apparent.

Measure of Success

Most civil and environmental engineering students are exposed to at least two classroom hours on decentralized wastewater treatment, and every state with a college or university teaching wastewater engineering has at least one institution with a well-attended decentralized design course.

3.1.2 Action: Universities or Other Organizations Teach Continuing Education Courses in Decentralized

Continuing education courses are a way for engineers who completed their university education without learning about decentralized wastewater treatment to obtain formal training. Cooperative Extension teaches such courses through regional training facilities in Rhode Island, Texas, and some other states. As land-grant universities add courses or modules about decentralized systems to their undergraduate curricula, they can work with Cooperative Extension offices to offer continuing education modules containing similar material.

Other organizations can administer courses in areas where universities are not prepared to offer instruction in decentralized wastewater treatment. The National Association of Wastewater Transporters (NAWT) offers one-day or two-day courses on inspecting decentralized wastewater treatment systems. While the course is designed for the practitioner, it could also be a useful introduction for engineers. The National Onsite Water Recycling Association (NOWRA) teaches a two-day course called "Onsite A-Z" in conjunction with its annual conference, which would also be a useful introduction. Local chapters of NOWRA may also have resources to offer similar courses on a smaller scale.

Steps

A major driver for continuing education demand is a requirement to take courses to retain a license or certification. State engineering societies could require member engineers to take continuing education courses in the areas they practice professionally to retain their certification; 31 states already have this requirement (National Society of Professional Engineers, 2005).

State regulatory engineers could also require that all designers of decentralized systems, whether or not they are licensed professional engineers, take continuing education courses. For example, Deb Knauss at Rhode Island Department of Environmental Management says that Rhode Island requires all designers—including licensed professional engineers—to demonstrate that they have received continuing education every two years, when they renew their licenses (personal communication). When this requirement was enforced for the first time in 2001, many lost their licenses for not meeting it. In March 2002, when the first Northeast Onsite Wastewater Treatment Short Course was offered in Newport, Rhode Island, it was attended by 120 Rhode Island designers, reports course organizer Tom Groves (personal communication).

The state or regional NOWRA chapters could also play a significant role, either in encouraging engineers to attend the "Onsite A-Z" course at NOWRA's annual conference or in encouraging engineering societies to organize their own training.

In New York State, regulatory, consulting, and manufacturers' engineers founded an Onsite Training Network to promote knowledge of decentralized systems.[12] It has been in existence since 1999, and its courses now attract over 400 students per year. The percentage of students who are PEs has increased since continuing education requirements were instituted; it began at 20% and now is at about 50% (Tom Boekeloo, New York State Department of Environmental Conservation, personal communication). Engineers in other states could set up a similar network.

Implications

Once practicing engineers are known to be educated about decentralized treatment, regulators are likely to put greater trust in the technology and systems. This is true both from regulatory engineers' participation in continuing education training and in the regulators' understanding that the professionalism of decentralized practitioners is increasing.

Measure of Success

This action will have succeeded in a state when in-state continuing education courses in decentralized wastewater treatment are regularly available to and attended by engineers.

3.1.3 Action: Increase Funding for University Decentralized Research

Only a handful of universities or state Cooperative Extension Services currently conduct research on decentralized wastewater treatment. These include Colorado School of Mines, Michigan State University, North Carolina State University, Texas A&M University, University of Arizona, University of California–Davis, University of Minnesota, University of Rhode Island, University of Tennessee at Knoxville, and University of Wisconsin–Madison. Lack of available research funding is a significant constraint, and funding shortfalls result both in less university-level instruction and in fewer well-qualified teachers in the decentralized field. Original research is also an important way to support graduate students, who then become the next generation of leaders in the field (John Buchanan, personal communication).

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[12] The Onsite Training Network's activities are documented at http://www.delhi.edu/corporateservices/otn_wastewater_programs_training_events.asp, accessed November 9, 2006.

At UW—Madison, for example, Biological Systems Engineering professor Jim Converse is now retired but still teaching his course on decentralized wastewater system design. He believes that his department will find someone to keep teaching it after he stops but doubts that the person will conduct decentralized research because there is so little funding available. Trina McMahon, Converse's colleague in the university's department of Civil and Environmental Engineering, concurs: "We might think more about onsite systems if there was more money available to do research on them. Our interests are guided completely by what National Science Foundation and the research arm of WERF fund, and that's activated sludge."

Increased research funding means that more university researchers have incentive to conduct basic research in decentralized systems and technologies. These researchers involve science and engineering students in their research, who become the next generation of "champions" for decentralized systems. Additionally, university instructors conducting original research in the decentralized field are likely well-qualified to teach courses in same, thus increasing the number of students exposed to decentralized wastewater treatment concepts. Even if these students do not immediately embark on a career in the decentralized wastewater field, they will have some knowledge of decentralized concepts and will be more likely to view them equitably with other options.

Steps

Increasing the available funding for decentralized research at universities is largely a question of allocation of resources, both within the federal government through U.S. EPA and the National Science Foundation, among others, and through external funding organizations like WERF. Engineers have a number of routes to influence these organizations to increase funding for decentralized wastewater treatment research.

- All types of engineers can work through their professional associations to lobby for more federal funding for decentralized research.
- Regulatory and other public sector engineers can work with legislators to fund university research in decentralized wastewater treatment, as has happened in Wisconsin.
- Engineers can become active in organizations like WERF and WEF (Water Environment Federation) to encourage more decentralized research.
- Manufacturers' engineers can encourage their companies to develop a funding pool to be used for independent research projects, eliminating worries of biases from one company funding a particular research project.
- Universities could seek new research partnerships with the U.S. EPA, or they could redirect existing research funding to incorporate decentralized systems.
- Universities and/or engineering societies could also provide recognition and rewards for particularly good decentralized research.

Implications

If engineers pressure funding organizations to increase research funding for decentralized systems, programs associated with other environmental or water-based issues may see decentralized wastewater as a competitor for funds.

Increasing research funding will require a particular focus on the role that research will play in lowering the overall cost of wastewater treatment. The gap between projected needs and funding for drinking water infrastructure looms large (U.S. EPA, 2002) and no obvious solutions have yet been offered. The situation for wastewater infrastructure is likely to be similar. If the wastewater industry could show Congress that the decentralized model has promise for reducing the size of the funding gap, greater funding may be appropriated for decentralized wastewater treatment research.

New and continued research would have a positive impact with the regulatory community. Regulatory programs and rules in some areas have evolved over time from the days when decentralized systems were viewed as temporary infrastructure. The more that can be done to increase the decentralized industry's professionalism, its science, its technology, and its ability to maintain infrastructure, the more regulatory systems will create models that promote and trust this solution. Research—and the availability of credible researchers—can greatly aid in this process.

Measure of Success

This action will have succeeded when researchers at 25 or more universities conduct research specifically on decentralized wastewater treatment.

One measure of success might be "proportional representation". If 30% of new housing in the U.S. uses decentralized treatment, decentralized research receives 30% of all total wastewater research funding.

However, it is challenging to identify what wastewater treatment research is on "decentralized" and what is on "centralized." Wastewater collection and treatment architectures are seen by many as a continuum, and they often use the same chemical or biological pathways. If research on activated sludge processes can be applied both to centralized treatment plants and manufactured components of onsite systems, how is the research classified? Rather than trying to carve out a percentage of wastewater research funding for decentralized, it is probably more useful to identify what decentralized research needs are (as NDWRCDP did (2001) and WERF is doing) and seek funding for them. Funding for priority areas for decentralized can thereby be integrated into research programs for centralized wastewater treatment and stormwater. For example, the current WERF research program areas of "Wastewater Treatment & Reuse" and "Watersheds & Water Quality" integrate research questions relevant to both centralized and decentralized wastewater treatment.

Increasing university research on decentralized treatment is also a means of improving the amount and quality of undergraduate education available on this subject. That approach will have succeeded when over half the environmental engineering departments with a wastewater course also offer two or more semester credits on decentralized treatment taught by someone who has published research in the field.

3.1.4 Action: Develop Decentralized Questions for the Professional Engineers Exam

The National Council of Examiners for Engineering and Surveying (NCEES) prepares the Fundamentals of Engineering (FE) and Principles and Practice of Engineering (PE) exams that are used in all states that recognize a certification in environmental engineering. The FE exam is generally taken at the time of graduation from a university engineering program, and the PE exam is generally taken after four or more years of experience working as an engineer.

According to Tim Miller (responsible for environmental engineering exams at NCEES, personal communication), the NCEES is open to receiving suggestions for exam questions about decentralized wastewater treatment. Any licensed P.E. can submit questions to the NCEES for consideration. Those engineers who want to become further involved can become an exam development volunteer.[13]

When the FE and PE exams include questions specific to decentralized wastewater treatment, engineering departments may become more motivated to cover it in their curricula.

Steps

As an individual, any type of engineer with a PE can volunteer to join the NCEES process and draw up decentralized design questions.

Societies with a special interest in decentralized wastewater, like NOWRA and ASABE (American Society of Agricultural and Biological Engineers), could set up a committee of people to develop questions related to decentralized design and forward them to NCEES or to an interested exam development volunteer. The Onsite Consortium's network includes many university faculty with experience giving their students exams on decentralized wastewater treatment; they could also form a committee for developing FE or PE questions related to decentralized systems and submitting them through the NCEES process.

Implications

Other programs, on hearing of this opportunity, will desire to gain access to this process to improve their industries as well.

An increased focus on training and testing will provide the regulatory community with evidence that the industry is increasing its professionalism.

Measure of Success

Questions related to decentralized wastewater treatment are contained in the FE and PE exams, as well as in study preparation courses for the FE and PE exams.

3.2 Strategy: Increase Data on Decentralized Technologies

The lack of widely available, documented knowledge has been a barrier to equitable consideration of decentralized systems. The availability of the knowledge is largely an educational question, addressed above (Section 3.1). Acquisition of new knowledge—research—is also a way to overcome this barrier.

Many areas of research have been identified as needed to improve the quality and acceptance of decentralized wastewater technologies (EPRI et al., 2001). One area that has immediate, practical implications for engineers designing wastewater treatment systems is the performance and reliability of decentralized systems and their components. When system performance is thoroughly documented, it becomes easier to compare different types of decentralized systems, or to compare centralized with decentralized collection and treatment.

[13] Details on this opportunity can be found at http://www.ncees.org/exams/volunteer/.

3.2.1 Action: A Management Entity Applies Reliability and Costing Tools to Decentralized Systems in an Asset Management Framework

Reliability of centralized water and wastewater infrastructure is receiving increased attention as the U.S. EPA promotes asset management strategies (U.S. EPA, 2004), which are credited with saving water and wastewater utilities much money in infrastructure maintenance and investment. There are relatively few studies of the reliability of decentralized technologies, and none that apply asset management techniques to decentralized wastewater treatment systems. A framework and tools for applying asset management to decentralized systems were recently developed in a project of the NDWRCDP (Etnier et al., 2005).

Asset management has been developed in fields where one organization (a private company or a public entity) owns the assets and maintains—or replaces—them. A number of RMEs (Responsible Management Entity) for decentralized wastewater treatment also have this structure; these RMEs could potentially be a laboratory where asset management can most easily be piloted for decentralized systems. A pilot project to apply the asset management framework to one or more existing RMEs would be a relatively easy but important step to establish more widespread use of asset management (Etnier et al., 2005).

Steps

The pilot project could be run by an RME or by a study team working closely with one or more RMEs. The Rural Community Assistance Partnership (RCAP) may be interested in performing the study or in disseminating its results. This project will build capacity in RMEs or jurisdictions to use asset management, in a setting where lessons from centralized treatment facilities are most easily transferable. The pilot project will also generate data on the reliability of the particular treatment technologies used by the RMEs.

Implications

Use of reliability, costing, and asset management tools in the decentralized wastewater treatment field may create both interest and concern from state watershed, stormwater, and community water programs: Government employees in these associated programs, many of whom are trained as engineers, will likely be interested in how these tools may be transferable to help them to better do their jobs. Conversely, there may be resistance in some programs to these tools being introduced into any related program.

It is likely that a move towards the use of asset management frameworks and reliability tools will also require new fiscal tools. The need for capital replacement funds based on asset life and performance, instead of on a fixed planning period, is one such example. Without regulatory oversight of the RME's fiscal practices, some RMEs may concentrate on short-term profit instead of using the tools described here to minimize long-term costs. This may further lead to the need for evaluation of return on investment and thus to pressure for RMEs or utilities managing such systems to come under a rate-setting regulatory structure.

This initiative will enhance the trust and acceptance of decentralized solutions in the regulatory community. The move to asset management will require different regulatory structures (e.g., more performance-based than prescriptive) for the business model to thrive, which may create a challenge. The regulatory community is more likely to accept different regulatory structures after the advantages of applying asset management and environmental management to decentralized systems have been proven, but applying asset management to decentralized systems may only work best with a more performance-based regulatory structure.

Measure of Success

This measure will have succeeded when the RME(s) participating in the pilot project actively use asset management to guide their investment and O&M decisions, and a report documenting the project is published.

CHAPTER 4.0

INCREASING THE FAVORABILITY OF THE REGULATORY CLIMATE FOR DECENTRALIZED SYSTEMS

Regulations and regulators (usually engineers) can present formidable barriers to equitable consideration of decentralized systems. The regulatory system for decentralized systems and technologies is complex and tremendously inconsistent both between and sometimes within states, yielding a system that is by turns too prescriptive, too lax, or too inflexible to enable good engineering practice and thus good experience with decentralized systems.

The regulatory environment can also affect public perception of decentralized wastewater treatment. Where systems are not properly designed/installed or not regularly maintained, there is a potential for failure rates to increase.

In addition, some people interviewed for this project found that many regulators tend to prefer what appear to be simple wastewater treatment solutions. Complex solutions, with multiple decentralized systems tailored to specific conditions across a community, will often be discouraged. This may be especially true if the regulators have limited knowledge about decentralized systems or if the management entity for the new systems is unproven or unavailable.

A major driver of the regulations for decentralized systems is the use of regulations to limit growth, which results in regulations that are not based on science and which may seriously limit consideration of decentralized systems.

Regulations also govern how public money is used to finance wastewater treatment projects; see Chapter 2.0 for barriers and strategies related to financing and the role of regulatory engineers.

Much work has been done on revising regulations, both within individual states and other jurisdictions and at the national level. This chapter addresses only broad changes that can lay the groundwork for future improvements in the regulatory climate. One strategy is to achieve greater state and local level uniformity in decentralized system regulations. A second engages environmentalists, who in some places have been primary opponents of science-based wastewater regulation because of growth issues. The third strategy focuses on improving the performance of treatment systems by ensuring these receive necessary O&M and that the organizations providing O&M are sustained.

4.1 Strategy: Achieve Greater Uniformity in Decentralized System Regulations

Regulations governing decentralized systems vary widely from state to state. In some states, individual counties or towns set their own regulations or have additional regulations. Regulations for decentralized systems usually contain such elements as:

- Determining site conditions (e.g., method of determining seasonal high groundwater table)
- Types of systems allowed to be installed, and often a process or data standards for approving innovative systems
- Design specifications for systems (e.g., design flow for a three-bedroom home) and system components (e.g., sieve analysis for mound sand)
- Installation and certification requirements
- Licensing requirements for designers, installers, and service providers
- Maintenance and monitoring requirements (if any)
- Permit renewal requirements (if any)

Requiring a single set of regulations for the entire nation would likely create more problems than it would solve. However, inconsistent standards have also been identified as a significant barrier to emerging technologies (Porter, 1980; quoted in Nelson et al., 2000), and this is true for innovative decentralized treatment technologies as well (Nelson et al., 2000). Manufacturers of treatment technologies incur significant costs because of the need to obtain certification for each state in which they operate, and that cost is increased when states do not accept data from systems operating in other states.

Achieving greater uniformity in decentralized system regulations is likely to increase regulators' knowledge of decentralized systems. More uniform regulations are only beneficial, of course, to the extent that the regulations are science based and lead to appropriate use and real management of decentralized systems. Otherwise, failures may occur more uniformly, and, as a number of interviewees observed, well-publicized decentralized system failures have led to skepticism about the technology among both engineers and the public.

Achieving greater uniformity in regulations requires regulators to consider the current science of wastewater treatment, so regulatory engineers have an opportunity to expand and update their knowledge. Where historical regulations have permitted systems that do not meet currently accepted design or O&M standards, updating the code improves the reliability of systems installed.

Greater uniformity of regulations would make it easier for consulting engineers to do business in the field—the cost of doing business over a widespread geographic area is less if the regulations are similar in the entire area. In this way, a consistent regulatory environment for decentralized technologies would encourage consulting engineers to more equitably consider decentralized systems. Several steps have already been taken to standardize practices and terminology in the decentralized wastewater treatment industry. Manufacturers of drip dispersal technologies worked on industry standards for features such as dripper flow rates and dripline spacing, with a goal of developing standards for treatment performance (Ruskin, 1999; quoted in Nelson et al., 2000). The National Precast Concrete Association (NPCA) recently adopted best management practices for concrete sewage tanks (Farrell-Poe and Deal, 2006). NOWRA is developing a model performance-based code that would change the prevailing philosophy of decentralized system regulations (NOWRA, 2004). Numerous organizations cooperated to develop a national credential for installers, and the Onsite Consortium has drafted a Decentralized Wastewater Glossary (Farrell-Poe and Deal, 2006).

The two actions described below build on work that is already done to increase the uniformity of regulations and terminology. Identifying a relatively small number of model regulations would make it easier for regulators planning future changes to make their regulations similar or identical to existing regulations, gradually leading to more uniform regulations from state to state. Completing a standardized, national glossary for decentralized wastewater also helps increase uniformity, by providing a common language for regulations, outreach materials, and other documents.

4.1.1 Action: Identify Model Regulations

When a municipality asks a consulting company like Stone Environmental to draft a local decentralized wastewater regulation, the consultants often begin by surveying existing, exemplary regulations for useful language to borrow. Companies which regularly draft regulations compile internal libraries of regulations that they borrow from, know the goals served by each regulation, and know how well or poorly many of them have worked. Making this type of information publicly available would make it easier for communities to draft regulations, and it would tend to make regulations more uniform.

The National Small Flows Clearinghouse manages a repository of state (not local) wastewater regulations.[14] The repository includes summaries of regulations and links to the regulations themselves. States, counties, or towns planning to revise their decentralized wastewater regulations can use the repository to draw ideas from the regulations of other states. Currently, the repository is descriptive, rather than evaluative. Engineers and state and local government officials, e.g., public health and environment staff, would benefit from guidance specifically written to help them revise and update decentralized wastewater regulations and codes. Such guidance could include information and recommendations on regulatory strategies, model language, and examples and case studies detailing implementation mechanisms that are practical, cost effective, easily implementable from an administrative perspective, and based on science and environmental and public health performance. A list of critical elements that communities should address in their regulations would also promote increased consistency on both a regional and national basis.

Steps

One approach to providing this guidance is to compile an annotated bibliography of a number of exemplary regulations, along with a guidance document evaluating their strengths, weaknesses, and any local political concerns they respond to (e.g., how to regulate growth without using the onsite wastewater code as surrogate zoning). The creation of such a guidance document could be undertaken by the National Environmental Health Association (NEHA), or WERF or the U.S. EPA could issue a request for proposals from anyone who has experience working with different regulations. NEHA recently partnered with other national organizations to develop a national credential for onsite wastewater system installers, to set a standard for both onsite wastewater system installation practice and knowledge of installers (*New credential will set national standard for onsite wastewater system installations*, 2005). Larry Marcum, responsible for governmental affairs at NEHA, says that the combined staff and member expertise at NEHA makes them well suited for such a task (personal communication).

A more ambitious approach would be to develop detailed guidelines that can be used by communities to craft each essential element in their decentralized wastewater regulations. For

[14] http://www.nesc.wvu.edu/NSFC/nsfc_regulations.htm accessed November 3, 2006.

example, model ordinance or regulatory language, processes and performance standards could be provided for the program elements described in Section 4.1, e.g., site condition evaluations, system designs, inspections and monitoring. U.S. EPA's Handbook for Managing Onsite and Clustered (Decentralized) Wastewater Treatment Systems (2005) already discusses important elements of regulations in detail, though no regulation language is offered. The U.S. EPA may be the most appropriate organization to carry forward the development of detailed guidance on decentralized regulations (Robert Goo, Nonpoint Source Control Branch, and Joyce Hudson, Decentralized Program, both at U.S. EPA; personal communication).

Implications

Regulatory programs will likely view such initiatives as a resource to assist the program and other partners in achieving desired outcomes.

Measure of Success

This action will have succeeded when either a guidance document or detailed guidelines on regulations has been published and is widely used by state and local regulatory agencies.

4.1.2 Action: Complete and Use the Decentralized Wastewater Glossary

Terminology relating to decentralized wastewater treatment technology varies considerably in different regions of the country. For example, the system component where effluent is dispersed into soil may be known as a leach field, a drainfield, a disposal field, a soil absorption system, soil-based dispersal system, or something else. Inconsistent terminology can hamper efforts to standardize regulations, training materials, guidance documents, and consumer information.

The Consortium of Institutes for Decentralized Wastewater Treatment (CIDWT, or "the Onsite Consortium") is developing a *Decentralized Wastewater Glossary (Glossary)*. A draft *Glossary* has been compiled and was presented at a workshop at NOWRA's annual meeting in August 2006. Manufacturing, regulatory, and other professional organizations are collecting review comments from their members, and individuals are also invited to review the draft. Phase II of the review process was scheduled for November 2006.

Steps

Completing the *Glossary* will be a significant milestone in developing nationally standardized terminology for decentralized systems. The next steps are for the *Glossary* to be disseminated throughout the industry and for engineers and other practitioners to adopt its terms in their system descriptions, regulations, extension documents, and other materials written about decentralized wastewater.

Engineers active in the Onsite Consortium, NOWRA, or any of the other societies involved in the reviewing the *Glossary* can email colleagues, write articles in their newsletters, give presentations, and otherwise publicize the existence of the *Glossary.*

Regulatory engineers can use rule changes to adopt the language of the *Glossary.*

Any engineer giving presentations or writing reports can make an effort to adopt the *Glossary*'s language.

Anyone who creates outreach documents on decentralized systems (e.g., regulatory, manufacturers', and university engineers) can use the *Glossary* to update the documents. The challenges in moving from regional terminology to a nationally standardized lexicon are perhaps most difficult in creating outreach documents. Outreach documents are designed to be understood by laypersons, and some words in the *Glossary* may not be initially recognized. For outreach materials produced at the state and local level, it will be important to have a transition period in which the local version of a term is, where different from the *Glossary*'s, added in parentheses.

Implications

Other programs may desire to add to the glossary or to create a second version to build on this initiative, positively integrating the decentralized industry with other programs.

Regulatory agencies will likely view such initiatives as an aid to assist the program and other partners in achieving desired outcomes. However, some may view this initiative as a drain on time or challenge to their authority.

Measure of Success

The action will have succeeded when the Onsite Consortium's *Glossary* is the accepted industry standard for decentralized wastewater terminology.

4.2 Strategy: Broaden Support for Science-Based Regulation of Decentralized Treatment

Environmentalists and the organizations that represent them have often been opponents of the decentralized approach to wastewater service provision, viewing decentralized wastewater systems as a threat to water quality compared to centralized systems. Some environmental groups also perceive decentralized wastewater treatment systems as an indirect threat to their goals, believing that the systems facilitate sprawl patterns of growth.

Environmental opposition to decentralized wastewater stems in part from a historical pattern in much of the U.S. of basing wastewater regulations and codes more on regulating growth than on using the best technology to protect human health and the environment. Planners or environmental organizations have found that it can be easier to use wastewater treatment regulations than zoning ordinances to constrain new development in an area. Development can thus be blocked when onsite regulations demand greater depth to groundwater or bedrock than can be supported on most or all lots. In these situations, cluster systems are often not encouraged, and no sewer or treatment plant exists nearby.

New developments in wastewater treatment technology have made it possible to develop lots with severe site limitations without compromising public health protection. A high level of treatment is obtained within two feet of mound sand, for example, or in devices like sand filters. The highly treated effluent can be dispersed in more finely textured soil than untreated effluent, especially when it is dispersed with evenly spaced dosing. However, where zoning does not exist or is difficult to enforce, there has been resistance to modernizing decentralized wastewater treatment regulations to reflect new knowledge and technologies. In Vermont and Wisconsin, for example, it took more than ten years to update decentralized wastewater treatment regulations and opponents raised fears of runaway development.

Where modernized regulations have been delayed by land use planning considerations, engineers in the wastewater community have wished to see the planners create enforceable zoning to protect the areas they want protected. Both Vermont and Wisconsin phased in their new regulations partly to allow additional time for changes to zoning regulations.

4.2.1 Action: Engage Environmental Groups and Planners to Support the Decentralized Approach

Engineers can build support among environmental groups and planners for modernizing regulations by showing how decentralized wastewater treatment strategies can now be used to attain land use goals that environmentalists and planners support, such as compact development in planned growth centers or planned communities.

The University of Rhode Island Cooperative Extension produced a well-illustrated manual with case studies of five typical planning situations faced by rural and suburban towns (Joubert et al., 2005).[15] The case studies presume that no centralized sewer is available for the area and show how decentralized wastewater treatment can be used to create desired development patterns. Each generalized case is illustrated by actual projects that use the design concept and technologies.

Decentralized systems also help avoid fiscal pressures for growth. Often a centralized system must be built with additional capacity to accommodate growth or to make it affordable by spreading the cost across current and future connections. Richard Rose (see Section 2.2.1.1), has seen on multiple occasions that local officials and residents were relieved to find that a decentralized approach could help them avoid building a system that requires growth and exposes them to financial risk if that growth does not occur.

Environmental organizations can be brought on board through engaging them on both the direct and indirect effects of decentralized wastewater systems. For example, the City of Malibu, California was incorporated in 1991 in part to prevent the state from requiring the area to be sewered, which residents thought would be costly and ineffective at improving water quality. By 2001, environmental groups like Heal the Bay and the Surfrider Foundation were reporting high levels of sewage indicator bacteria at both Malibu Lagoon and Surfrider Beach and blaming the city's onsite and cluster wastewater treatment systems. A stakeholder team developed a plan to monitor and model the groundwater flows to establish whether the bacteria detected were, indeed, from the treatment systems. Before the monitoring and modeling began, the City and its consultants spent time in both public and private meetings with the environmental organizations, to hear their concerns and to inform them of the project and the treatment capabilities of soil-based treatment systems. Representatives from Heal the Bay provided valuable input before the final report for the project was completed, and were supportive of the project's recommendations for managing decentralized systems in the City of Malibu.

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[15] The manual is based on a project of the NDWRCDP, and the results are described in a somewhat different way in the final report for that project (Joubert et al., 2004). The manuals can be downloaded or ordered as hard copies at http://www.uri.edu/ce/wq/mtp/html/publications.html (accessed October 31, 2006).

Steps

The persons who can best “make the case” to state environmental group leaders are well-versed in decentralized systems and seen as relatively unbiased with respect to different types of wastewater systems. In Malibu, Robert A. Rubin, a professor at North Carolina State University on “loan” to the U.S. EPA Office of Water, was extremely effective as an outside expert trusted by both the City and the environmental organizations. Consulting engineers may also be effective in this role. If anything, they may be received as potentially biased toward centralized systems since they typically receive larger fees for such systems. Consulting engineers can also engage state planning organizations, both through the organizations’ conferences and newsletters and through local planners.

An effective forum for consulting engineers to engage and educate environmental group leaders and planners is in a task force convened by the state around regulatory or programmatic changes. For example, in Vermont an Onsite Sewage Committee helped educate environmentalists, planners, and many other stakeholders. Peg Elmer, Director of Planning at the Department of Housing and Community Affairs, described how the committee worked (personal communication). She co-chaired the committee with a consulting engineer, and the committee was open to anyone who wanted to participate. About 30 people regularly attended the meetings, and around 120 received mailings about it. The education that took place in the committee helped form a coalition for new onsite regulations that the state Agency of Natural Resources could not ignore. While the process did not convince the state’s largest land use advocacy organization to support the regulations, it did turn a number of regional and state planners into champions for the new regulations.

In the absence of a current proposal for regulatory or programmatic change, a “roundtable” format for exploratory conversations on the issues could be used. Engineers acting through a statewide professional engineering organization could convene such a roundtable, or ask another respected party, such as a policy center at a university, to do so. In either case, participation by university engineering professors could add neutrality and credibility to the effort.

A useful tool in each state would be to customize manuals like the University of Rhode Island Cooperative Extension’s manuals on decentralized wastewater for planners, so they reflect each state’s planning and wastewater regulations. For example, the Maine’s Planning Office has developed their own set of white papers and fact sheets. Vermont’s Agency of Commerce and Community Development has secured funding to do something similar through the U.S. EPA Healthy Communities grant program (Peg Elmer, personal communication).

Once state environmental leaders and planners are convinced, consulting engineers, agency engineers, and others who advocate regulatory change would be in a better position to build on the relationships formed in the initial effort. Consulting engineers and municipal engineers would also be in a better position to affect the views of local environmental groups by calling on state environmental leaders who were engaged previously.

Implications

As connections between the decentralized approach and water reuse or low impact development arise, criticism may be leveled that the current literature does not adequately address this comprehensive approach. Reuse criteria already exist in many states, but valid questions may be raised over whether various onsite or decentralized technologies can reliably meet the performance criteria required for safe reuse. Additionally, regulatory managers may not be comfortable with discussions suggesting that their regulations are not, or were not, science based and were a tool of land use planning.

Measure of Success

This action will have succeeded when key environmental groups in each state at a minimum do not oppose properly designed decentralized wastewater systems or legislative and agency regulation and guidelines changes to encourage such systems. Ideally, environmental groups actively encourage municipalities and regulators to seriously consider decentralized options.

4.3 Strategy: Manage System Information: Permits, Maintenance, Inspections, and Monitoring

There has been a significant investment nationwide in the siting and installation of wastewater treatment systems, yet accessing information about these systems is difficult because these are largely privately owned, privately funded, and sporadically regulated systems. Regulatory agencies have not had a consistent approach over time to managing information on the location, site conditions, and components of decentralized systems that are installed. Most of the information resides in filing cabinets with limited retrieval capability. If the permitting organization uses a database, its primary purpose generally is tracking permit submittals and approvals, not managing system information. A number of pressures are now forcing a fresh look at information management as a key component of managing decentralized infrastructure.

Conventional onsite wastewater treatment systems, where the septic tank and laterals are the only treatment components, can provide years of trouble-free service when properly designed and installed. Some maintenance is nonetheless required to keep them operating well, including periodic pumping of the septic tank, cleaning of the effluent filter (if any), and replacement of any septic tank tees that break. An advanced system with moving parts (e.g., pumps or blowers) has more potential for breakage, and such systems are becoming more common. For these reasons, the U.S. EPA recommends a management program for decentralized wastewater treatment systems (U.S. EPA, 2005). Lack of any management program is often a symptom of a weak regulatory environment, which can result in inadequate or failure-prone decentralized systems.

A management program requires information about what is being managed. There are a number of proprietary and freeware information management databases designed to keep track of where decentralized systems are, what their designs are, and what maintenance, inspections, and monitoring they have received. Such information management systems are a fundamental tool in a management program, and achieving more widespread use of these tools will enable a level of management that can prevent failures. Databases are typically used by regulatory agencies to track permit status and for some enforcement, but they will be more useful cores of management programs when they also track O&M activities.

Where regulators are reluctant to consider decentralized systems because of the complexity of managing so many different installations, the availability of easy-to-use management tools may make decentralized options more attractive.

4.3.1 Action: Regulators Promote High-Quality Permit, Maintenance, and Monitoring Programs

A number of databases have been released for tracking and managing decentralized wastewater treatment systems. In Massachusetts, SepTrack was developed in the 1990s for use by local boards of health. A number of private companies offer customizable, web-based databases that have been used at both the municipal and the state levels, or sell database services related to decentralized wastewater system management. The U.S. EPA has also released a free database developed in Microsoft Access called “The Wastewater Information System Tool” (TWIST).

Some administrators of these databases update use them every day in managing their decentralized systems, while others have tried the databases for a while and abandoned them, mainly due to lack of staff time. Publicized stories of successful tracking programs and the databases used could help identify what is necessary for a management database to succeed.

Steps

Conferences for the regulatory community, such as the annual State Onsite Regulators’ Alliance (SORA) Conference, are an extremely important means of sharing information with and between regulators. Successful regulatory data management initiatives could be presented in a half-day or day-long seminar in connection with NOWRA’s annual conference or with SORA’s annual meeting. Municipal users of various tracking databases and manufacturers with databases could present their experiences, including evaluations of the strengths and weaknesses of their data management systems and how to obtain resources to implement tracking programs. A panel discussion could be held at the end of the seminar to summarize lessons learned, both for those who wish to use tracking databases and for database developers.

Reporters at Small Flows, Onsite Water Treatment, or another publication could produce an article or series of articles promoting success stories of permitting agencies using data management systems to track decentralized system O&M activities.

After the initial presentation of the successful programs through either a seminar or an article series, a task force could be formed to produce a short description of lessons learned in using the databases and recommendations to those who wish to start using them.

Implications

Many water and environmental programs have data needs similar to those of decentralized system regulators. For example, many cities face such needs with MS4 (Small Municipal Separate Storm Sewer Systems) stormwater management regulations. Where appropriate, combining data management systems into one that is multifunctional may offer cost efficiencies and higher and more sustained use.

The cost of information management has been a barrier to sustained use of database and information management systems in the past. The costs of robust software and maintaining and entering data into the system are significant when multiplied by hundreds or thousands of individual systems. A prime barrier has been lack of resources for data entry, coupled with a lack of the skills needed to get useful output from the system in the form of reports. Adequate funding is essential to successful implementation of data-driven systems. Building the information management system's costs into maintenance rates, fees, or other such mechanisms will be necessary to implement the tools.

State and local permits for advanced treatment systems or decentralized systems with large daily flows often carry a requirement for data tracking and system monitoring. A database that a regulatory engineer can use to easily check the status of ongoing permit compliance requirements will increase the credibility of the industry.

Measure of Success

This action will have succeeded in a state when most regulators of decentralized systems are aware of multiple options for setting up a tracking program and know where to look for information on details of individual programs.

4.3.2 Action: Regulators Evaluate Simplified Tracking Databases and Publicize Them If they are Helpful

Obtaining access to a tracking database is often the first hurdle for states and local authorities to overcome when they seek to monitor O&M for decentralized systems. To address this issue, Massachusetts made a standalone database called SepTrack available free to local boards of health in the state in the 1990s. The U.S. EPA released TWIST in 2006. Such freeware does not provide all the functionality that customizable proprietary programs can provide, and little technical support is provided. However, freeware may be exactly what authorities need to start tracking decentralized systems. The free software may be enough to support a tracking program indefinitely. Such software may also entice the user to upgrade to a proprietary web-based program that allows remote access for multiple types of users such as homeowners, pumpers, and maintenance vendors.

Steps

As of late 2006, around a thousand copies of TWIST had been distributed by the U.S. EPA (Rod Frederick, U.S. EPA, personal communication). They have little information about how many organizations are using it now, but plan to publish a web site to collect and post comments from users. In mid-2007, the U.S. EPA should contact the jurisdictions that requested the program and ask them to post their experiences and evaluations with TWIST or other database applications to that web site. If TWIST or other programs have significant success in helping authorities manage and track decentralized systems, that should be publicized through the means suggested above (Section 4.3.1) or other means.

Implications

The implications are identical to those in Section 4.3.2.

Measure of Success

The evaluation part of this action will have succeeded when the U.S. EPA has sufficient information to evaluate how helpful various decentralized information management software applications have been to jurisdictions that wanted to institute management for permitting and tracking of decentralized wastewater treatment systems.

If these tools are judged to be helpful, the publicizing part of this action will have succeeded when the majority of those who wish to institute tracking programs are aware of the most successful information management tools.

4.3.3 Action: Manufacturers' Engineers Track Operation and Maintenance of their Systems

Where states or municipalities have not taken responsibility for tracking information about decentralized systems, manufacturers may do so. One major manufacturer of decentralized treatment components tracks O&M on its systems using an in-house database, and several others are interested in using databases to track maintenance. Tracking maintenance helps the manufacturers ensure that their systems receive required maintenance and continue to perform properly (Chuck Resevick of Aquapoint, personal communication).

When responsible manufacturers move forward with improved tracking, they will help ensure the function and longevity of their systems even where regulators do not track O&M. Other manufacturers may they be forced to follow that lead in order to remain competitive. Greater monitoring by manufacturers may either make tracking by regulatory authorities less necessary, or it may push tracking toward a "tipping point" (Gladwell, 2002) where it becomes widely used within regulatory agencies.

Steps

Orenco Systems, Inc. and other manufacturers already use in-house databases or spreadsheets for tracking O&M on their systems. Engineers for other major manufacturers of decentralized system components could adopt one of the many available databases (Section 4.3.1) and insist that their distributors use it.

Implications

Other water programs such as groundwater protection, TMDLs, and watershed-based programs may desire to gain access to this information to assist with programmatic decision-making.

Manufacturers may complete this action to the limit of their self interest with no other implications.

Regulators will be interested in data collected by manufacturers and may require submission of such data as part of approval processes to allow installation of new technology. As tracking systems are installed in greater numbers, and as manufacturers have more data in the tracking systems, regulators are likely to want access to the data in greater detail.

Measure of Success

This action will have succeeded in a state when all advanced treatment systems or other pump-based systems requiring regular maintenance are tracked and the tracking system is used to ensure preventive and reparative O&M activities occur in a timely way.

CHAPTER 5.0

INCREASING SYSTEMS THINKING

Both centralized and decentralized wastewater treatment systems may adequately treat and disperse wastewater—as they are designed to do—and still cause environmental, public health, or economic problems. Potential problems arise in unintended consequences elsewhere. For instance, stormwater sewers built to prevent flooding have been charged with exacerbating drought (Otto et al., 2002), and regulations for onsite wastewater treatment systems in the absence of careful zoning have led to unintended sprawl (e.g., Johnson, 2002). The unintended consequences may also be missed opportunities or increased costs, for example, in a water-restricted region where efficiency measures are not taken or where wastewater is treated and discharged rather than treated to reuse quality and recycled directly to non-potable uses.

Engineers are good at understanding systems *as they are defined in their design problems.* Wastewater or stormwater collection and treatment systems are, of course, systems. However, the system boundaries are often drawn narrowly and do not encourage awareness that water systems are components of a broader system, one consisting of other infrastructure, resources, and planning processes in a community or watershed. Other components of the broader system include land use zoning and plans, as well as infrastructure such as roads, stormwater systems, and water distribution systems. Parameters to consider in a broader systems context may include population growth, biological and environmental conditions, and other local planning goals.

Few engineers get training in or develop an orientation toward broader systems—the ecosystems, economic systems, and political systems present in a community or watershed. As Bob Zimmerman of the Charles River Watershed Association describes stormwater and water supply engineering, the conventional engineering approach "that treats rainwater as a liability, disconnects rainwater from groundwater with impervious surfaces, and transports locally drawn potable water to distant locations for treatment and discharge" is the fundamental problem (quoted in Pinkham et al., 2004).

Lack of systems thinking is the most influential of the categories of barriers to engineers giving equitable consideration to decentralized wastewater treatment systems, because it significantly affects the other three categories of barriers:

- ♦ Financial reward: Decentralized wastewater solutions have a large array of potential benefits that are only captured if the system analyzed is defined more broadly than it usually is. Consulting engineers who exercise broader systems thinking are likely to be the ones to find business models incorporating decentralized wastewater—as NorthStar Engineering has (see Section 1.2.2).
- ♦ Engineers' lack of knowledge: If university engineers applied broader thinking to their curriculum development, decentralized wastewater would likely be part of the education of every engineering graduate.

- Unfavorable regulatory climate: regulators applying broader systems thinking are more motivated to find ways to make their regulations more hospitable to the use of decentralized systems.

Broader systems thinking can change the way engineers practice wastewater engineering at the site level, the community level, and the watershed level.

Engineers employing systems thinking at the site level can expand on their current considerations for wastewater choices by considering what type of system might meet the owner's energy goals (by using passive systems, or more efficient pumps) or water use goals (by employing irrigation re-use in arid areas). They will learn and incorporate stormwater low-impact development (LID) practices. Consulting engineers can seek LEED certifications (see Section 5.2.3) for their site plans, which can lead to a new way to market their services.

On the community level, municipal and utility consulting and regulatory engineers can use systems thinking in wastewater decision-making by including wastewater considerations along with other water resource planning and through improved wastewater facility plans and using integrated water resource planning.

On the watershed level, engineers using systems thinking may look at decentralized wastewater options as a means of meeting TMDL limits in surface waters, maintaining water balances in groundwater and surface waters, reducing constructed infrastructure needs, reducing energy consumption, and improving local asset management capability to meet goals established in environmental management systems.

The three strategies discussed for increasing systems thinking in the engineering community include both mandates and opportunities. Wastewater planning documents can be required to include sections that address relationships between each wastewater alternative and other water sectors, such as drinking water, stormwater, ground water, and surface water. In some situations, this broader consideration of impacts will highlight advantages of a decentralized alternative. Utilities can also find ways to reward the most cost-effective approaches to managing water resources—which sometimes will include decentralized treatment. Finally, engineers both at the university and in their continuing education can improve teaching of systems thinking skills.

5.1 Strategy: Require Wastewater Planning to Include Relationships to Other Water Sectors

Municipal or regional planning for wastewater usually begins with a needs assessment, where present and projected future wastewater flows are described and the capacity of present infrastructure to accept and treat these flows is evaluated. If the needs assessment does not take broader systems into account, they are most likely also to be ignored in the proposed engineering solutions. A minimum way to incorporate broader systems thinking into wastewater needs assessment is to consider drinking water and stormwater management needs at the same time. These are linked with land use, so desired future development is important to consider as well. Colchester, Vermont successfully linked multiple sectors in one project to protect Malletts Bay, a bay of Lake Champlain that provides recreational, scenic, and other benefits to the town. Voters rejected a bond vote to install sewers along much of Malletts Bay because many were skeptical that the $10 million project would actually improve water quality. The Town Select Board then appointed a Water Quality Committee composed of both sewer opponents and sewer proponents to recommend a new approach. After educating themselves on the issues, the committee commissioned a Strategic Water Quality Plan (SWQP), which examined present and projected future needs for stormwater, wastewater, and land use, plus the impact of boating on water quality. It also recommended ways to address these issues. The SWQP thus incorporated both a needs assessment and alternatives analysis. Drinking water was not considered, since most of the town is on municipal water drawn from another point on Lake Champlain where Colchester has a relatively small impact (Stone Environmental Inc., 2003). The Town is now carrying out an Integrated Water Resources Project which incorporates many of the recommendations from the SWQP and uses new methodologies for needs assessment and alternatives analysis.

Alternatives analyses could be improved by providing a more detailed and equitable consideration of decentralized wastewater treatment options (as discussed in Section 2.1.1). Alternatives analysis can also be improved by considering the opportunities that wastewater treatment options present to address issues or constraints with water supply, stormwater, and land use. One example of addressing water supply and wastewater simultaneously is the New England Patriots' football stadium in Foxboro, Massachusetts (Patriots' new stadium…, 2002; Ed Clerico, personal communication). It was built in an area with limited water supply and limited capacity for wastewater dispersal. Because it recycles 80% of the treated water to non-potable use, the wastewater treatment system is able to handle demand while preserving capacity for future development in the area.

Consulting engineers are more likely to give decentralized options equitable consideration if they are monitored to make sure they follow guidelines for considering treatment alternatives (see Section 2.2.1). When those guidelines include consideration of effects in other water sectors, decentralized solutions may receive credit for advantages that are missed in a conventional comparison of alternatives. Hence, the action is to develop guidelines on how to consider the effects of wastewater solutions on other water resources.

Massachusetts is a good example of how new policies can encourage broader systems thinking.[16] In eastern Massachusetts, centralized drinking water, storm water, and wastewater systems have lowered the groundwater enough in some watersheds that rivers run extremely low in the summer, and one even stops flowing entirely. In 1984, the Interbasin Transfer Act prohibited transfer of wastewater outside a river basin unless all in-basin treatment options have been exhausted, water conservation has been pushed to its practical limits, and other measures are taken. In 1996, the Massachusetts Department of Environmental Protection developed its Comprehensive Wastewater Management Plan (CWMP) process. The process requires communities to examine the full range of alternative wastewater collection and treatment systems when examining solutions. Many towns have since considered how to use decentralized systems to meet growth and/or water quality goals.

5.1.1 Action: Develop Guidelines for Linking Wastewater to Other Sectors

The examples above show that it is possible for engineers to produce or commission needs assessments and alternatives analyses that apply systems thinking to water. Such approaches may become more widespread at least in part through the revision of guidelines like

[16] This account is drawn from Pinkham et al. (2004).

RUS Bulletin 1780 (see Section 2.2.1.1) to address incorporating systems thinking in both the needs assessment and the alternatives analysis.

The guidelines would be more useful to the engineers using them if they contained examples of where planning across water sectors has worked well and where there were severe consequences from not planning across water sectors. *Valuing decentralized wastewater technologies: A catalog of benefits, costs, and economic analysis techniques* (Pinkham, Hurley et al., 2004) catalogs advantages and disadvantages of decentralized wastewater treatment that most engineers may not have considered, and some of the points of that volume would also be useful to include. The examples and analysis could be in an accompanying document, rather than in the guidelines themselves. The accompanying document might also contain examples of consulting engineers with business plans that capitalize on their ability to perform broader systems thinking, like NorthStar Engineering (Section 1.2.2).

RUS is one candidate for developing these revised guidelines through their normal review process for Bulletin 1780. According to Jim Maras, Director of RUS' Water Programs Division (personal communication), their bulletins are generally reviewed every five years by a team of RUS field staff who work with them. The staff recommends revisions, and senior RUS staff chooses which of the recommendations to include in a proposed revision. From there, federal government rulemaking procedures are followed: the proposed rule is published and there is a public comment period, after which the proposed rule is reconsidered in light of the public comments and issued. The RUS is reviewing Bulletin 1780 at the time of this writing (Fall 2006), and they hope to publish a proposed rule sometime in the period April through June 2007. Suggestions for revisions may be sent either before the proposed rule is published or during the public comment period.

Other candidates are states with primacy for implementation and enforcement of the Safe Drinking Water Act and Clean Water Act. Each primacy state, according to Maras, has guidelines similar to RUS 1780 for facilities plans. The review team for that state could make changes that are applicable within the state. One or more pioneering states might make the changes first, so that other states and the RUS can evaluate the effects before acting.

Steps

Developing the guidelines is the first step in implementing this action. The following steps will be helpful in making sure the guidelines are useful.

Once the guidelines are completed, a group of 5-15 "first adopter" regulatory and community engineers apply the guidelines in requests for proposals (RFPs) to consulting engineers and enforce them in the subsequent projects. They meet every six to twelve months (possibly via webcast or conference call) to learn from each others' experiences. After enough time to see a significant number of PERs through to completion (perhaps three years), they either recommend the guidelines as they are or recommend specific changes.

When a number of examples have been created through the process described above, implementation of the guidelines can be facilitated by any of the following measures:

- ♦ Regulators can require that comprehensive water planning be a part of the scope of wastewater planning projects. This could be effective where regulators are educated about comprehensive water planning and are motivated to require it. Where regulators are less educated or motivated to require comprehensive planning, even a requirement will be ignored. For example, the National Environmental Policy Act (NEPA) requires alternatives to be considered, but often they are not given serious consideration unless a vigilant watchdog organization insists (Jon Groveman, General Counsel at Vermont Natural Resources Council, personal communication).[17]

- Public sector engineers in funding agencies can require consulting engineers to consider relationships between each wastewater alternative and other water sectors, and make payment contingent on consulting engineers meeting criteria for including this consideration (See Section 2.2.1).
- Alternatively, funding could be provided preferentially for wastewater planning and construction where watershed/water resources approaches are incorporated into master planning. For example, the town plan must identify wastewater problems to qualify for grant funding through state housing and community affairs departments. Additional funding through Clean Water Act Section 319 (Nonpoint Source Management Program) may be available for those plans. Many states also have funding available for watershed planning. Targeted funds like the Great Lakes funding or Ocean and Coastal Resource Management funding could be used where available.
- Engineering societies can promote a comprehensive planning approach. A very simple measure is a link to watershed management tools or to the guidelines described above on societies' web pages (e.g., American Public Works Association's Resource Center http://www.apwa.net/ResourceCenter). Another is for engineering societies to address the comprehensive planning approach in their conferences.
- U.S. EPA can add the guidelines to their web page on "Technical Tools for Watershed Management" (http://www.epa.gov/owow/watershed/tools/).

Implications

These guidelines would revolutionize how programs work together and/or are designed. From programs to regulations to fiscal and human resources, moving to guidelines requiring whole systems to be evaluated will involve substantial change. An inclusive process, extensive learning, and careful redesign will be necessary to ensure acceptance and continued compliance with federal and state environmental and health laws.

Moving to a holistic approach holds great promise for utilizing currently available funds to best meet the environmental and health needs of the country. Convincing Congress to take on the type of overhaul necessary to update laws and funding programs to accomplish this task will be challenging. However, with the funding gap for water infrastructure looming large (U.S. EPA, 2002), the time is right to put bold initiatives before leaders and to advocate for a more systemic approach. Front-end development costs would rise, but construction and maintenance costs are likely to be reduced. More important, an appropriate infrastructure that meets the needs of a particular challenge will be employed, as all issues and needs will be considered.

Much can be accomplished, however, without change directed by Congress. The RUS 1780 guidelines can be changed through rulemaking procedures, and guidelines for feasibility studies in states with primacy for Clean Water Act can be changed at the state level. Action from regulatory engineers will be needed to connect funding for PERs or feasibility studies to adherence to the guidelines.

[17] The NEPA process is required for federally-funded wastewater projects.

Implementing such guidelines would not require an overhaul of regulatory or permitting structures. Only a commitment to evaluating impacts of wastewater projects on other water sectors is necessary. Expertise in new disciplines, such as societal and environmental costing, would become necessary both for regulatory engineers and consulting engineers. Engineering, planning, and economic analysis firms would need to team up with each other and often with scientific and economic partners to satisfy these analysis needs. To build broad support for such initiatives, the regulatory programs will also need to involve the public.

Measure of Success

This action will have succeeded when guidelines have been developed and used in at least several different jurisdictions for five years, to the satisfaction of municipal clients, consulting engineers, and regulatory engineers.

5.2 Strategy: Utilities Encourage Integrated Water Resources Approaches

When barriers to equitable consideration of decentralized wastewater treatment are removed, the appropriate wastewater treatment system will generally be used. Or, to put it another way, wastewater treatment systems will be chosen based on local water resource management and land use planning needs—whether they are resolving an existing water pollution or supply problem, creating a more sustainable approach, promoting local growth, restricting growth, or finding the least expensive solution regardless of other effects. Vagaries of regulations, financing, and business capabilities or interests will not get in the way of using the desired solution.

Furthermore, the appropriate wastewater treatment system will be creatively designed and take advantage of any cross-sector impacts from drinking water and stormwater systems. In fact, any water infrastructure could be designed as a “water resource system,” not only as a drinking water, wastewater, or stormwater system. For example, in an arid region, there might be compelling advantages to treating wastewater to reuse quality using decentralized systems and then recycling the water locally in landscape irrigation to avoid strains on potable water supplies. Decentralized systems with reuse might be the most cost-effective solution because of reduced potable water use, where such systems might be too expensive if potable water reuse component was not considered. Conversely, a centralized system may be preferred in some situations, to increase the return of water to a river or because of the possibility of substituting treated water for large amounts of potable water, for example, in industry or large-scale irrigation.

A utility with responsibility for all water resources, if appropriately regulated, would have an incentive to find least-cost ways of meeting local drinking water, wastewater, and stormwater requirements. Where opportunities for stormwater and/or wastewater reuse are attractive, the utility has the incentive and ability to install the reuse treatment facility and distribution pipes. Where the land has capacity to infiltrate either wastewater or stormwater—but not both—at any time of the year, the utility can plan accordingly for off-site treatment of runoff or effluent.

A water resource utility can combine systems thinking with public involvement and the search for a least-cost method of achieving level-of-service goals, in a way that has already been done in water supply utilities (Section 5.2.1). This action makes broader systems thinking a part of the utility's mission, and is likely to widen the scope of alternatives considered for new infrastructure.

A second action is for utilities to investigate offering developers incentives for water reuse, as New York City does (Section 5.2.2). Local reuse can make decentralized treatment more cost effective, and developers may be more likely to employ local reuse if they receive financial incentives for doing so.

The third action is for utilities and local government entities to give incentives to build "green" buildings i.e., with LEED certification. LEED certification gives designers an incentive to become more creative in their systems thinking (Section 5.2.3).

5.2.1 Action: Utilities Employ Integrated Resource Planning

Integrated resource planning (IRP) uses least-cost analysis of options for meeting utility functions, e.g., supply of potable water or treatment of wastewater or stormwater (Vickers, 2001; Beecher, 1995). IRP was developed for the U.S. electrical industry in the 1980s to compare the cost of reducing energy demand with that of increasing electricity generation (supply). A fundamental premise of IRP is that the utility can treat increased supply and conserved demand as equivalent. Demand management—decreasing the level and/or timing of water or energy use—is central to IRP. Ways to promote conservation include changes in consumer behavior (e.g., turning off the faucet while brushing teeth) or changes to more efficient infrastructure, e.g., showerheads, toilets or light bulbs.

While IRP has primarily been used by water supply utilities, there is room for incorporating wastewater and stormwater. According to Lindsey (1996), IRP for water resources "involves simultaneous consideration of all hydrologic and engineering processes that affect the resource, including water supply, wastewater treatment, stormwater management, and other processes or uses such as cooling, navigation, low flow augmentation, recreation, flood control, and environmental management." Lindsey also provides a framework for integrating stormwater into IRP. Integrated resource planning has also been applied in water utilities, including using demand reduction as a means of reducing the need for sewage treatment plant upgrades (White, 2001).

A promising way to introduce IRP into utility planning processes is through the asset management process, which the U.S. EPA's Office of Water is encouraging utilities to adopt (see Section 3.2.1). The EPA defines asset management for wastewater utilities as "managing infrastructure capital assets to minimize the total cost of owning and operating them, while delivering the service levels that customers desire. It is successfully practiced in urban centers, and large and small sewer collection systems to improve operational, environmental, and financial performance."[18] Tools for asset management include a database for tracking the infrastructure components, maps of systems, failure analyses, life cycle calculations for system components, and detailed costs of both capital investments and O&M.

The five "core questions" for asset management are (Parsons/GHD Asset Management Center, 2003):

1. What is the current state of my assets?

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[18] This definition, and many other resources for asset management, can be found on the EPA's web site at http://www.epa.gov/owm/assetmanage/index.htm (accessed November 14, 2006).

2. What is my required sustained level of service?
3. Given my system, which assets are critical to sustained performance?
4. What are my best minimum life-cycle-cost CIP (capital improvement plan) and O&M strategies?
5. Given the above, what is my best long-term funding strategy?

The fourth question, on the least-cost combination of capital investments and O&M, is where IRP can start. On the fringes of a utility's service area, the least-cost investment may be maintaining onsite systems or building cluster systems.

Steps

The simplest step in using the asset management process to promote more equitable consideration of decentralized wastewater treatment is for utility engineers to develop and use guidelines on how to consider decentralized solutions. If the RUS-type guidelines described in Section 5.1.1 have already been created, they could adopt or adapt those. No IRP process is necessary in this case; the guidelines simply provide an expanded set of supply-side wastewater treatment options to be considered.

To a limited extent, exactly this situation is occurring on the fringes of Melbourne, Australia. Roger Byrne of GHD (personal communication), who has assisted water and wastewater utilities in the U.S. and Australia with asset management, says the asset management process has led the Melbourne utility to adopt the small-diameter sewers used in cluster systems on the fringes of its service area. In Melbourne, the sewers ultimately convey effluent to a regional treatment plant. The septic tanks were left in place, and small-diameter vacuum sewers connect the houses with the conventional gravity sewer.

A more complete way to incorporate systems thinking into the asset management process is for the utility to use IRP when defining the level of service (asset management's core question #2, above). Asset management typically defines a level of service for the function for which a utility's customers pay it. For example, water supply utilities define level of service in terms of how clean the water is, how much can be supplied, and how few interruptions in service there are. Wastewater utilities define level of service in terms of meeting the requirements of a discharge permit while rarely allowing sewage to back up into buildings. Following Lindsey's (1996) description (above) of IRP applied to water resources, water utility engineers should consider including other factors in their definition of level of service. The other factors might include how the local hydrologic cycle is affected by water withdrawals and discharges. Utility engineers might also consider redefining the scope of the utility to include stormwater management.

IRP is especially suited for approaching revisions in level of service, because it is not just a technical process. IRP employs public involvement in discussing environmental impacts and tradeoffs between alternatives, which effectively puts the level-of-service discussion squarely into the public realm.

Pinkham et al. (2004) provide language to use in an expanded definition of level of service. They catalog a host of potential benefits and costs of different choices of wastewater treatment. Level of service could be defined in terms of any of these benefits, e.g., community autonomy, support of local economies, hydrologic impacts, surface water quality, public health, a part of the utility's mission, and is likely to widen the scope of alternatives considered for new infrastructure.

A second action is for utilities to investigate offering developers incentives for water reuse, as New York City does (Section 5.2.2). Local reuse can make decentralized treatment more cost effective, and developers may be more likely to employ local reuse if they receive financial incentives for doing so.

The third action is for utilities and local government entities to give incentives to build "green" buildings i.e., with LEED certification. LEED certification gives designers an incentive to become more creative in their systems thinking (Section 5.2.3).

5.2.1 Action: Utilities Employ Integrated Resource Planning

Integrated resource planning (IRP) uses least-cost analysis of options for meeting utility functions, e.g., supply of potable water or treatment of wastewater or stormwater (Vickers, 2001; Beecher, 1995). IRP was developed for the U.S. electrical industry in the 1980s to compare the cost of reducing energy demand with that of increasing electricity generation (supply). A fundamental premise of IRP is that the utility can treat increased supply and conserved demand as equivalent. Demand management—decreasing the level and/or timing of water or energy use—is central to IRP. Ways to promote conservation include changes in consumer behavior (e.g., turning off the faucet while brushing teeth) or changes to more efficient infrastructure, e.g., showerheads, toilets or light bulbs.

While IRP has primarily been used by water supply utilities, there is room for incorporating wastewater and stormwater. According to Lindsey (1996), IRP for water resources "involves simultaneous consideration of all hydrologic and engineering processes that affect the resource, including water supply, wastewater treatment, stormwater management, and other processes or uses such as cooling, navigation, low flow augmentation, recreation, flood control, and environmental management." Lindsey also provides a framework for integrating stormwater into IRP. Integrated resource planning has also been applied in water utilities, including using demand reduction as a means of reducing the need for sewage treatment plant upgrades (White, 2001).

A promising way to introduce IRP into utility planning processes is through the asset management process, which the U.S. EPA's Office of Water is encouraging utilities to adopt (see Section 3.2.1). The EPA defines asset management for wastewater utilities as "managing infrastructure capital assets to minimize the total cost of owning and operating them, while delivering the service levels that customers desire. It is successfully practiced in urban centers, and large and small sewer collection systems to improve operational, environmental, and financial performance."[18] Tools for asset management include a database for tracking the infrastructure components, maps of systems, failure analyses, life cycle calculations for system components, and detailed costs of both capital investments and O&M.

The five "core questions" for asset management are (Parsons/GHD Asset Management Center, 2003):

1. What is the current state of my assets?

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[18] This definition, and many other resources for asset management, can be found on the EPA's web site at http://www.epa.gov/owm/assetmanage/index.htm (accessed November 14, 2006).

The step of incorporating IRP into asset management will have succeeded at a utility when the level of service definition incorporates services beyond water supply and wastewater collection and treatment. Another measure is that engineers working for or advising water and wastewater utilities automatically consider reuse as a way of addressing engineering issues such as park irrigation or overloaded pump stations or sewers.

5.2.2 Action: Utilities Investigate Offering Developers Incentives for Water Reuse

Reuse of treated wastewater offers an effective means of conserving high-quality freshwater supplies while helping to meet growing demands for water. Water reuse can also allow greater water *use* in an area with limited capacity for wastewater treatment and dispersal. Many communities throughout the United States and the world are using or considering water reuse for uses such as landscape and agricultural irrigation (including residential lawns, parks, and athletic fields), toilet and urinal flushing, industrial processing, power plant cooling, wetland habitat creation or restoration, and groundwater recharge (U.S. EPA, 2004).

Ed Clerico, president of Alliance Environmental, has designed water reuse systems using membrane bioreactors for over 15 years. His experience is that when water reuse systems are designed, engineers automatically start applying water sector systems thinking (personal communication). The systems, however, do not fall neatly within “water supply” or “wastewater” categories, and so the design questions become broader. Hence, encouraging water reuse is a small but significant step to providing regulatory, municipal, and consulting engineers with experience in systems thinking in the water sector.

New York City is exemplary for its approach to reuse water, according to Clerico—the regulatory burden of doing so is light. The New York City Department of Environmental Protection and the New York City Department of Health have decided to apply neither the Clean Water Act nor the Safe Drinking Water Act to reuse water. When sewers are “mined” for water that is treated and then used for non-potable uses, no new discharge has been created. Hence, the Clean Water Act does not apply. And the water for non-potable uses is not, by definition, drinking water, so the Safe Drinking Water Act does not apply, either. Instead, U.S. EPA guidelines for water reuse, including purple pipes for the reuse water, are applied.

Applied Water Management (AWM) runs one such system in a 39-story residential apartment building (The Solaire, 20 River Terrace, Manhattan). Clerico, who founded and later sold AWM, says that the exact design of their treatment system is of no more concern to regulators than the exact design of a cooling tower (personal communication). The system has a function, and whatever technology that AWM chooses to use to fulfill that function is permissible, providing the reuse water meets established reuse water quality. AWM performs some “light duty” monitoring and reporting of the water quality to the authorities, but Clerico says maintaining customer satisfaction becomes the real “enforcement mechanism.”

In addition to reducing the regulatory barrier for reuse water, New York City offers a 25% discount on a building’s water and sewer bill if the building incorporates reuse (Ed Clerico, personal communication). Clerico explains, “The discounts are based on metered billing; both the water and sewer charges are determined from the water meter readings. The incentives are offered because the water reuse systems are capitalized and operated entirely by private funds, yet these systems provide reduced demands on both the public water and wastewater systems and on future public capital spending.”

Water reuse has developed a certain cachet in New York City, with a growing number of developers wanting to incorporate it in their buildings (Clerico, personal communication). The 25% discount on the water and sewer bill makes reuse more financially attractive, and the freedom from prescriptive design regulations for reuse systems allows innovation that reduces costs further.

While incentives for reuse may encourage systems thinking, they can also result in inefficient investments. In Australia, a "green building" rating system called GreenStar gives incentives to reuse water—the greater the amount of reuse, the higher number of points awarded. That distribution of points sends the message that more reuse is always better, yet efficiency of *use* is often less expensive than reuse or increasing supply (White, 2001; White and Fane, 2002; Mitchell et al., 2004).

Steps

Utility engineers can investigate reuse incentive programs in places like New York City to determine the true cost of the "new water" they generate—including the incentives, the reuse infrastructure, and any avoided expansion of other water and wastewater infrastructure. These costs will then be useful in planning ways to make most efficient use of reuse and other tools.

Implications

Implementing incentive programs will result in new costs, and adequate funding of any recommended incentive program will be central to its success. Some of the energy efficiency models may prove to be transferable to systems thinking about water resources. In energy efficiency, two main models have been used: 1) a line charge paid by all users that funds efficiency programs, and 2) higher overall rates that result in less efficient users paying more. Either concept could work for creating incentives for water reuse. As has been the case with energy efficiency, lower O&M costs are likely to offset the higher upfront costs.

Measure of Success

Encouraging reuse makes sense where water supply or wastewater dispersal capacity are limited because of local environmental conditions or regulatory requirements like TMDLs, or in areas of growing water use where reuse costs less than increasing water supply or treatment capacity. For such an area, this measure will be successful when in-depth analysis of water reuse options becomes a standard part of subdivision and commercial building designs.

5.2.3 Action: Utilities Encourage LEED Certification for New Construction and Renovation

Ed Clerico praises the potential of designing projects to meet the U.S. Green Buildings Council's LEED system, because "people do things because they want to, not because they have to," and that helps unleash creativity (personal communication). LEED stands for "Leadership in Energy and Environmental Design," and it is a system that measures claims that a building is “green.” LEED has been applied primarily to commercial and public buildings, and a draft rating system has been developed for residences.[20]

LEED assigns points to many different aspects of building design, from site choice (for new buildings) to landscaping, energy efficiency, and water use. Depending on how many points a building receives, it can receive simple LEED Certification, or LEED Silver, Gold, or Platinum status.

Under the draft rating system for residences, 12 of the 108 possible points relate directly to water efficiency, and additional points are possible for stormwater-related aspects of site design. Nadav Malin, chair of the LEED Materials and Resources Technical Advisory Group (personal communication), says that what helps designers’ creativity is flexibility in the different ways that points can be accumulated.

LEED ratings may be attractive to clients because they add value to new construction and renovation projects. National Geographic Society renovated their headquarters to LEED Silver and documented an increased market value for the property of $4 for every $1 invested. “The Society added $24 million in value from this LEED certification from higher appraised value, raising tenant rents, lower operating costs, increased credit ratings, and lower interest rates on debt instruments,” according to Chris Liedel, Chief Financial Officer for National Geographic Society (U.S. Green Building Council, 2004).

Increased market value of a building does not necessarily show that the choices made are the most efficient for water resource infrastructure. As described above (Section 5.2.2), achieving the highest number of points in a rating system like LEED may not reflect the most efficient investments for achieving water resource goals. However, most LEED points in water resources are for efficiency, which is often the least-cost way to achieve water resource goals (White, 2001; White and Fane, 2002; Mitchell et al., 2004).

Steps

Utility engineers can recommend that their utility find ways to encourage developers to consider adopting LEED certification as a design goal in all their projects. Possible ways include distributing information about LEED to developers, offering technical assistance on the water aspects of LEED design, and offering financial incentives (e.g., lower hookup fees for LEED buildings).

There is a role in LEED promotion for other engineers, as well. Consulting engineers who wish to apply systems thinking in the water sector can promote LEED to their commercial and residential clients.

In addition, consulting or utility engineers may wish to offer input to the U.S. Green Building Council on revising rating systems to recognize decentralized wastewater treatment systems as a viable alternative to sewers. The draft rating system for residences, for example, gives one point for “Site within 1/2 Mile of Existing Water, Sewer, and Roads,” as if connection to a sewer is assumed.

[20] U.S. Green Building Council has extensive resources on the LEED rating systems at http://www.usgbc.org/DisplayPage.aspx?CMSPageID=75&, accessed November 6, 2006.

Implications

LEED building certification requires designers and engineers from many disciplines to work closely together, so cooperation across disciplines becomes a prerequisite.

If this initiative falls to regulatory engineers to implement, they may raise concerns due to their current work load, unless staffing levels and resources necessary to implement the change are provided. If, however, consulting engineers and their clients take the initiative, regulatory engineers will likely favorably receive it.

Measure of Success

This action will have succeeded in a state when developers consider using LEED certification as a design goal in a majority of all new construction or renovation projects.

5.3 Strategy: Train Engineers in Broad Systems Thinking

Systems thinking in water resources issues does not seem to be part of the undergraduate engineering curriculum, and engineers do not have many opportunities to develop such skills on the job. Above, guidelines were suggested for helping engineers apply systems thinking and for presenting utilities with responsibility for all aspects of water planning (Section 5.1.1). Engineers with some ability to apply broader systems thinking are necessary for these strategies to be most effectively applied to water resource issues. The guidelines are a type of training in themselves, but engineers with previous experience are more likely to be successful in applying the guidelines.

Section 3.1 describes ways to train engineers in *decentralized wastewater technologies*. This section concentrates on training engineers in *systems thinking*. Some of the examples and ideas are drawn directly from the water and wastewater sectors. Others are adapted from related efforts to teach sustainability as a design constraint[21] or as part of engineering ethics. Exercises for improving skills in evaluating sustainability can improve the engineer's skill in applying systems thinking to the water sector, since the water sector is one part of what must be considered in evaluating overall sustainability. Since evaluating engineering ethics requires broader considerations than simple design problems, ethics training is likely to build habits of thought conducive to systems thinking in the water sector.

Future engineers can be reached most effectively through their undergraduate training. Kevin White, Chair of the Department of Civil Engineering at the University of South Alabama, views his students as potential decision makers starting about ten years after they graduate (personal communication). He tries to lay the groundwork in their undergraduate education for making them receptive to decentralized wastewater technologies when they reach that point. In order to further such efforts, some changes are suggested for the undergraduate curriculum itself and for the extra-curricular opportunities available to engineering students.

Currently, practicing engineers have continuing education requirements in 31 states (National Society of Professional Engineers, 2005), and they have opportunities for continuing

[21] ABET and NSPE recognize the importance of engineers learning how to apply sustainability as a design constraint. NSPE has even added the following clause to their Code of Ethics for Engineers: "Engineers shall strive to adhere to the principles of sustainable development in order to protect the environment for future generations" (NSPE, 2006).

education even when it is not required. Changes for continuing education programs are also discussed.

5.3.1 Action: Train Undergraduate Engineers in Broad Systems Thinking

The University of Vermont (UVM) recently finished the first year of a project funded by the National Science Foundation to incorporate systems thinking into its civil and environmental engineering curriculum. A School of Engineering brochure defines systems thinking as “a way of seeing and working with systems instead of breaking these into pieces. For civil and environmental engineering, this means incorporating the environmental, social, political, regulatory, cultural, and economic factors within the engineering solution, as well as the problem definition.” The core of the approach is the use of service learning in many courses—students work in groups to provide an engineering service to the community, while applying what they have learned in the course. For example, the water and wastewater course for the spring 2007 semester may have a design project helping a nearby Vermont community with many houses on small lots surrounding a lake determine what sort of treatment systems are most appropriate.

Also at UVM, many of the individual engineering courses have been integrated into related systems courses, which they plan to begin teaching in the spring 2007 semester. Three courses—Transportation, Engineering Economics, and Introduction to Environmental Engineering—have been reorganized into integrated systems courses: Environmental and Transportation Systems, Decision Making in the Environment and Transportation, Modeling Environmental and Transportation Systems.

The UVM team is also exploring how to assess what difference this systems approach makes in how their students think. The principal investigator on the project (Nancy Hayden, personal communication) says, “We want to change the way students think—and how do we assess that? Do they have a different attitude about engineering—do they think about social implications of this bridge or the environmental implications of this roadway?”

Another area that can offer models for systems thinking in the water sector is sustainable development. Defined as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (World Commission on Environment and Development, 1987), sustainable development has wider support and recognition than systems thinking in the water sector alone. For example, “sustainable development” is a widely recognized term in international agreements and programs through agencies like the United Nations Environmental Program. Engineering educators who wish their students to apply systems thinking to the water sector could do well to find allies within the sustainable development world who apply systems thinking well beyond the water sector.

According to Mulder et al. (2005), sustainable development (SD) has been integrated into engineering education at the Technical Universities of Barcelona (Spain), Monterrey (Mexico), and Delft (Netherlands). “These Universities were front riders in SD. They expressed strong commitments to make SD the cornerstone for educational reform. Although the plans were developed independently, they look rather much alike, [and] they have in common: A basic course for all (or most) students, stipulating that SD is addressed in 'ordinary' courses, [and] the option of specialization in SD.”

Partial adoption of the three-pronged approach used in Barcelona, Monterrey, and Delft is also possible. A version of the stand-alone course, the first prong, is described by Mitchell (1996): A course for first-year engineering students that incorporates the social and environmental consequences of engineering decision making into technical decision-making processes, using life cycle assessment and structured controversies.

Davis (1999) recommends a "pervasive" method of teaching engineering ethics, which corresponds to the second prong of the Monterrey/Delft approach to sustainable development. Davis calls for frequently repeated, small doses of thinking that he calls "hit-and-runs," and provides tips on how to generate them. A useful project would be to generate a book of such "hit-and-runs" related specifically to systems thinking in the water sector. Brinckerhoff's *One-minute readings: Issues in science, technology, and society* (1992) provides a format that could be imitated: a short amount of background information and a question to leave the class with at the end of the period.

Design courses in engineering provide a further opportunity to teach systems thinking skills. The Texas A&M case study, "A Plow For Mexican Peasant Farmers," assigns students to design a motorized plow for Mexican peasant farmers that works well on hillsides, is easy to operate and maintain, and costs less than $1,000.[22] As they devise designs that meet those criteria, students are invited to consider a host of related questions, such as whether a motor, humans, or animals will be used to pull the plow, and whether the design is sensitive to the gender of the operator. The design exercise and its accompanying questions could be used as a model for water-related design exercises, e.g., design a wastewater treatment system for a new subdivision on the outskirts of a city in an arid climate, and add the other dimensions that it takes to move the answer beyond traditional design.[23]

There are also opportunities outside the curriculum to inject systems thinking. Two of the ethics teaching methods recommended by Davis (1999) inspired the following suggestions:

- A special event, for example, a public speech on water issues or a movie like *Thirst*[24] with a discussion afterward.
- Hold students to a sustainability code while they are still students. It might be a pledge to keep the student's ecological footprint to a certain size, or to eat a diet consisting of food from within the school's watershed or some other local geographic region. The code should emerge from the students as much as the faculty. Davis says, "Students should have a part in administering it. There should be frequent opportunities to discuss its interpretation, to apply it to particular cases of student conduct, and to evaluate it in light of that experience."

[22] http://ethics.tamu.edu/ethics/plow/plow.htm

[23] Richard Rose of the New Mexico Environment Department describes an ongoing project in Corrales, New Mexico that might be adapted to a design problem (personal communication). The community has discussed the planning implications of replacing their onsite systems with a sewer. Would it mean that a big box store would move to town, and do they want that? A centralized sewer system would also require a river discharge, and that would invoke costly monitoring requirements. One community member calculated that for a small fraction of the several million dollars proposed for the sewer, the town could buy everyone in the service area an efficient washing machine, and that might reduce flows to the point where continued subsurface discharge is possible. With the community in the sixth year of a drought, the water conservation aspect of this plan is also attractive.

[24] http://www.bullfrogfilms.com/catalog/thirst.html

Within environmental engineering, the watershed approach to diagnosing and solving pollution problems offers potential examples of systems thinking that could be used in undergraduate teaching (see, for example, http://www.epa.gov/owow/watershed/). Yellow Wood Associates' Green Community Technologies program offers case studies of municipal infrastructure approached from a systems perspective, including a wastewater example in Hinesburg, Vermont (Yellow Wood Associates, n.d.).

Steps

Individual university engineers can adapt and adopt any of the examples or topics described above into their existing courses—not just into water and wastewater courses.

University engineers can work outside the curriculum, as advisors to student groups or in other ways, to put on special events that foster systems thinking or hold students to a sustainability code, as described above.

A more ambitious effort is for university engineers to reorganize their engineering curriculum around systems thinking, applying the lessons of the UVM project. The UVM effort is funded by a $100,000 planning grant from the National Science Foundation, followed by a grant of $860,000 to complete the project. While departments that learn from UVM's process will benefit from not re-inventing some things, there will still be a significant initial investment.

An alternate but also ambitious project is for university engineers to organize their engineering curriculum around sustainable development, using the model from Monterrey and Delft. This effort, too, would require a significant initial investment.

Implications

In the long term, private and public sector engineers will arrive on the job better suited to connect issues across sectors, providing an easier path to implementing many of the initiatives from other parts of this report.

For decades, many engineering schools have considered moving to a five-year curriculum to cover those issues already of interest.[25] Issues of systems thinking and decentralized infrastructure will add to that debate. It is not resolved whether adding subject diversity requires additional time in school, or rather if the diversity of topics enriches the engineer and can be accomplished with less practice of the traditional topics. If the decision is to move to a five-year program, the resulting fiscal and life decisions for young people could result in fewer students enrolling in engineering schools.

Measure of Success

Measuring success at changing the way students think about engineering problems is more difficult than measuring mastery of specific topics of engineering knowledge. UVM engineering faculty member Nancy Hayden believes that their program is breaking new ground in developing methods to measure whether their curriculum changes have succeeded in teaching

[25] The National Council of Examiners for Engineering and Surveying (NCEES), which develops the P.E. licensing exams, voted in September 2006 to support a requirement of 30 credits over a four-year degree before engineers take the P.E. exam (Rubin, 2006).

the habit of systems thinking. When the UVM program is completed, in 2009 or 2010, there will be a model for measuring success.

5.3.2 Action: Train Practicing Engineers in Broad Systems Thinking

The National Society of Professional Engineers (NSPE) has commissioned a 16-hour continuing education course on "Essentials of Sustainable Design." Developed by Malcolm Lewis at CTG Energetics, the course includes a two-hour module on water. The course is available as an on-demand webcast, with slides and narration by Malcolm Lewis and a discussion from the original, live webcast at the conclusion. The water module covers:

- Background on the impending water crisis
- Metrics for water performance
- Water efficiency
- Reclaimed water
- Wastewater treatment
- Graywater systems
- Water-efficient landscaping
- Irrigation & controls

While the module is too short to introduce much detail or allow discussion of the interactions between wastewater treatment and other parts of the water sector, it provides an overview of enough different ways to handle water to stimulate the engineer to find out more.

Steps

It would be useful if consulting, regulatory, and university engineers involved in wastewater sought out "Essentials of Sustainable Design" or similar courses when planning their continuing education.

The next step might be a 16-hour course, expanding on the water module's content, which is suitable for continuing education credit. Mary Maul, Director of Education at NSPE (National Society of Professional Engineers), says that the 16-hour course on sustainable design represents the level of detail that NSPE is comfortable working with. WERF, ASABE, NOWRA, or the Onsite Consortium may be appropriate organizations to produce a more detailed course. One of these organizations could also produce a list of existing courses similar to the "Essentials of Sustainable Design" water module.

Implications

Over time, engineers in all sectors will become more familiar with systems thinking. This will assist individual engineers to connect issues across water and environmental programs and requirements and may result in positive change.

Training will assist regulators to see the necessity of changing rules and processes to accommodate systems thinking. However, tremendous leadership will still be required to break down traditional separations between water-based regulatory agencies.

Some states do not have continuing education requirements for engineers. In these states, it may be more difficult to reach the intended audience.

Measure of Success

This action will have succeeded in a state when most engineers who work regularly with water issues have either studied a systems approach to water in their university training or received at least several hours of pertinent continuing education.

CHAPTER 6.0

COMMUNICATIONS PLAN AND ACTION SUMMARIES

Engineers are in a position to make significant changes in the extent to which decentralized wastewater treatment receives equitable consideration. There are roles for all the types of engineers considered in this study: consulting engineers, regulatory and other public sector engineers, community/utility engineers, university engineers (teachers, researchers), manufacturers' engineers, and engineering societies and similar organizations. The tables in this section summarize the roles for each type of engineer or organization in implementing the actions identified.

6.1 Dissemination Plans

The actions identified in this report will only happen if the key players understand the reasons for and take responsibility for them. The project team has attempted to spread word of the project's analysis and preliminary results during the project and to build "champions" for the project's success. These efforts will and must continue if the goals of this project are to be realized.

Champions within the decentralized wastewater industry were enlisted to identify and prioritize significant barriers through various means, including:

- Interviews with over 25 prominent people in or familiar with the decentralized industry
- A 90-minute forum at NOWRA's 2005 annual conference
- A day-long meeting with manufacturers' engineers at Orenco's headquarters in Oregon

Champions also helped to generate and prioritize solutions, through

- Creation of a Stakeholder Sounding Committee to rank strategies and actions to address the most significant barriers
- A presentation and discussion at NOWRA's 2006 annual conference
- Many additional interviews with new and previously contacted experts

Other ways the project team has drawn attention to the ongoing project include a keynote presentation at the Ontario Onsite Wastewater Association's annual conference, articles in WERF's *Laterals* and *Progress*, an article in RCAP's *Rural Matters*, and discussions on the U.S. EPA's "Decentralized" listserv.

The results of this project are scheduled to be presented at a one-day workshop at RCAP's annual conference in Long Beach, California in February 2007. A shorter presentation will be made nationally through a WERF web seminar, announced to and through the people and organizations contacted in the course of this project. Further potential avenues for dissemination include

- WEFTEC poster session

- Distributing the recorded web seminar
- Distributing outreach handouts
- WERF fact sheet(s) on the project
- WERF-sponsored workshops to implement specific actions
- A final article in *Progress* and/or *Laterals*

6.2 Tabular Summary of Roles in Implementing Actions

The following tables summarize the barrier categories and actions to be taken, along with the engineering types and organizations who can implement the actions.

Table 6-1. Roles of Individuals and Organizations in Increasing Engineers' Financial Compensation for Using Decentralized Systems.

Strategy	Action	Roles of Individuals and Organizations
2.1 Increase availability of financial assistance for decentralized systems	2.1.1 Implement funding set-asides and project review and ranking criteria that remove biases and encourage greater use of decentralized systems	**Consulting engineers** through an **engineering society** or **funding agency engineers** instigate changes in funding agency procedures. In states where regulatory agencies assist funding agencies in project review, **regulatory engineers** also help develop project review guidelines. **Funding agency engineers** spread information about the changes, once they are made.
	2.1.2 Implement new loan fund models	**Consulting engineers** aid communities that need funding for individual properties but cannot get it through conventional programs in arguing for change at the funding agency. **Consulting engineers** provide technical information to legislature and, through a state **engineering society**, draw in state **regulatory** and **financing agency engineers**. **State regulatory** or **financing agency engineers** provide technical information to legislature.
	2.1.3 Establish tax credits for onsite system upgrades	**Consulting engineers** provide facilitate approach to legislators through providing technical information on the need for onsite system replacements and upgrades or arranging participation by state regulatory or financing agency personnel.
2.2 Require consideration of decentralized options in regulatory and funding processes	2.2.1 Require serious consideration of decentralized options in facility plans	**Funders or engineering societies** investigate whether the changes can be made in agency guidelines or require more formal rule-making or statutory changes. **Engineering societies** identify engineers to sit on outside advisory panels for facility plan review. Once requirements are in place, **regulatory or funding agency engineers** inform consulting engineers.
2.3 Increase public awareness and address perceptions around decentralized systems	2.3.1 Educate local government officials on the financial advantages of decentralized systems	**Consulting engineers** use information generated in the facility planning process to educate officials and municipal engineers. **Municipal engineers** use information from **consulting engineers** to educate local decision makers. **State and federal agency engineers** who have regulatory or funding roles help educate local officials and/or municipal engineers. **Service provider engineers** (e.g., those with the Rural Community Assistance Corporation) can play a similar role.
2.4 Adopt new business models for engineering	2.4.1 Implement alternative marketing	**Consulting engineers and firms** consider and adopt alternative marketing strategies.

Strategy	Action	Roles of Individuals and Organizations
firm success with decentralized systems	strategies	**Consulting engineers** "spread the word" about alternative marketing strategies through presentations at **engineering society** meetings and articles in society periodicals **University engineers** include presentations by or profiles of successful engineers in their syllabi.
	2.4.2 Implement alternative ways to compensate engineers for recommending decentralized systems	**Consulting engineers and firms** consider and adopt alternative business models. **Consulting engineers** "spread the word" about alternative business models through presentations at **engineering society** meetings and articles in society periodicals **University engineers** include presentations by or profiles of successful engineers in their syllabi. **Consulting engineers** identify and address any regulations and policies that need to be changed for certain models to succeed.

Table 6-2. Roles of Individuals and Organizations in Increasing Engineers' Knowledge of Decentralized Systems.

Strategy	Action	Roles of Individuals and Organizations
3.1 Increase teaching of decentralized systems	3.1.1 Universities teach engineering students a minimum of two classroom hours in soil-based treatment and decentralized technologies	**The Onsite Consortium** publishes materials for one- to three-lecture introductions to decentralized for civil engineering courses. **Wastewater textbook authors** incorporate a chapter on decentralized. **Consulting engineers** work through their university alumni associations to encourage the universities to teach a course or module on decentralized treatment. **Regulatory and other public sector engineers** work with legislators to fund instruction in decentralized design at state universities with engineering programs. **Consulting engineers—or qualified engineers in any other part of the field**—contact engineering faculty members and offer to provide guest lectures on decentralized.
	3.1.2 Universities or other organizations teach continuing education courses in decentralized systems	**State professional engineer societies** require that their members take continuing education courses in the areas they are active in professionally, to retain their certification. (Some state societies have continuing education requirements for their members; others have none.) **State regulatory engineers** require that all designers of decentralized systems take continuing education courses. **State or regional NOWRA chapters** encourage engineers to attend the "Onsite A-Z" course at NOWRA's annual conference or organize their own training. **Regulatory, consulting, and manufacturers' engineers** found an Onsite Training Network to promote knowledge of decentralized systems.
	3.1.3 Increase funding for university decentralized research	**All types of engineers** work through their professional associations to lobby for more federal funding for decentralized research. **All types of engineers** become active in organizations like WERF and WEF to encourage more decentralized research. **Manufacturers' engineers** encourage their companies to develop a pool of manufacturers' funds to be used for research projects, eliminating worries of biases from one company funding a particular research project. **Universities and/or engineering societies** provide recognition and rewards for particularly good decentralized research.
	3.1.4 Develop decentralized questions for the Professional Engineers exam	**Any type of engineer with a PE** volunteers to join the NCEES process and draw up decentralized design questions. **Societies with a special interest in decentralized wastewater**, like NOWRA and ASABE, set up a committee of people to

Strategy	Action	Roles of Individuals and Organizations
		develop questions related to decentralized design and forward them to NCEES or to an interested exam development volunteer. **Onsite Consortium's network of university faculty** with experience giving their students exams on decentralized form a committee for developing FE or PE questions related to decentralized and submitting them through the NCEES process.
3.2 Increase data on decentralized technologies	3.2.1 An RME applies reliability and costing tools to decentralized systems in an asset management framework	**An RME**—or a study team working closely with one or more RMEs—runs a pilot project.

Table 6-3. Roles of Individuals and Organizations in Increasing the Favorability of the Regulatory Climate.

Strategy	Action	Roles of Individuals and Organizations
4.1 Achieve greater uniformity in decentralized system regulations	4.1.1 Identify model regulations	National Environmental Health Association (NEHA) compile a number of exemplary regulations, along with a guidance document evaluating their strengths, weaknesses, and any local political concerns they respond to (e.g., how to regulate growth without using the onsite wastewater code as surrogate zoning).
		U.S. EPA develop detailed guidelines with recommended approaches for each function of regulations.
	4.1.2 Complete and use the Decentralized Wastewater Glossary	**Engineers** active in the Onsite Consortium, NOWRA, or any of the other societies involved in reviewing the *Glossary* can email colleagues, write articles in their newsletters, give presentations, and otherwise publicize the existence of the *Glossary.*
		Regulatory engineers use rule changes to adopt the language of the *Glossary.*
		Any engineer giving presentations or writing reports can make an effort to adopt the *Glossary*'s language.
		Anyone who creates outreach documents on decentralized systems (e.g., regulatory, manufacturers', and university engineers) can use the *Glossary* to update the documents.
4.2 Broaden support for science-based regulation of decentralized treatment	4.2.1 Engage environmental groups and planners to support the decentralized approach	**Consulting engineers** "make the case" to state environmental group leaders.
		Consulting engineers engage and educate environmental group leaders in task forces convened by the state around regulatory or programmatic changes. This was the approach taken in Vermont.
		In the absence of a current regulatory or programmatic change proposal, **engineers** acting through a statewide professional engineering organization could convene a "roundtable" format for exploratory conversations on the issues. Alternatively, they could ask another respected party, such as a policy center at a university, to do so. In either case, participation by university engineering professors would add "neutrality" and credibility.
		Consulting engineers and agency engineers advocate regulatory change once state environmental leaders are convinced, and build on the relationships formed in the initial effort.

Strategy	Action	Roles of Individuals and Organizations
		Consulting engineers and municipal engineers affect the views of local environmental groups by calling on state environmental leaders who were engaged previously.
4.3 Manage system information: Permits, maintenance, inspections, and monitoring	4.3.1 Regulators promote high-quality permit, maintenance, and monitoring programs	A half-day or day-long seminar, perhaps in connection with NOWRA's annual conference or SORA's annual meeting.
		Reporters at Small Flows, Onsite Water Treatment, or another publication produce an article series.
		A task force is formed to produce a short description of lessons learned in using the databases and recommendations to those who wish to start using them.
		U.S. EPA contact the jurisdictions that have requested the TWIST program and ask them to post their experiences and evaluations to a web site set up for that purpose.
		Publicize TWIST's successes in helping authorities track decentralized systems, through the means suggested in Section 4.3.1.
	4.3.2 Regulators evaluate simplified tracking databases and publicize them if they are helpful	**Major manufacturers** adopt one of the many available databases (Section 4.3.1) and insist that their distributors use it.

Table 6-4. Roles of Individuals and Organizations in Increasing Systems Thinking.

Strategy	**Action**	**Roles of Individuals and Organizations**
5.1 Require wastewater planning to include relationships to other water sectors	5.1.1 Develop guidelines for linking wastewater to other sectors	**RUS field staff** suggest revising Bulletin 1780 to include linking wastewater to other sectors. **Any interested engineer** recommends changes to RUS. In states with primacy for Safe Drinking Water Act and Clean Water Act, **consulting and regulatory engineers** on the review team for feasibility plans recommend changes. *When the guidelines are completed*, "first adopter" **regulatory and community engineers** apply the guidelines in RFPs to consulting engineers and enforce them in the subsequent projects. **Regulatory engineers** require comprehensive water planning be a part of the scope of wastewater planning projects. **Funding agency engineers** require **consulting engineers** to follow the guidelines. **Funding agency engineers** provide funding preferentially for wastewater plans and construction where watershed/water resources approaches are incorporated into master planning. **Engineering societies** promote comprehensive planning. **Regulatory engineers** at U.S. EPA promote the guidelines
5.2 Utilities encourage integrated water resources approaches	5.2.1 Utilities employ integrated resource planning	**Utility engineers** develop or adopt guidelines that require serious consideration of decentralized treatment in expanding the service area. **Utility engineers** and other staff expand the definition of "level of service" in asset management to include broader, IRP goals. The **regulatory engineers** at U.S. EPA incorporate IRP and more systems thinking into asset management presentations.
	5.2.2 Utilities investigate offering developers incentives for water reuse	**Utility engineers** investigate reuse incentives to determine the true cost of the "new water" they generate.
	5.2.3 Utilities encourage LEED certification for new construction and renovation	**Utility engineers** recommend that their utility find ways to encourage developers to consider adopting LEED certification as a design goal in all their projects. **Consulting engineers** promote LEED to their commercial and residential clients.

Strategy	Action	Roles of Individuals and Organizations
		Consulting or utility engineers provide input to the U.S. Green Building Council on revising rating systems to recognize decentralized wastewater treatment systems as a viable alternative to sewers.
5.3 Train engineers in broad systems thinking	5.3.1 Train undergraduate engineers in broad systems thinking	**University engineers** challenge students to use systems thinking in their existing courses.
		University engineers help put on special events that foster systems thinking or hold students to a sustainability code.
		University engineers reorganize their engineering curriculum around systems thinking or sustainable development.
	5.3.2 Train practicing engineers in broad systems thinking	**Consulting, regulatory, and university engineers** include "Essentials of Sustainable Design" or similar courses in their continuing education.
		WERF, ASABE, NOWRA, or the Onsite Consortium produces a more detailed continuing education course.
		WERF, ASABE, NOWRA, or the Onsite Consortium produces a list of existing courses similar to the "Essentials of Sustainable Design" water module.

APPENDIX A

METHODS

A.1 Phase 1: Identifying the Barriers

An extensive literature has documented the barriers to decentralized wastewater treatment (see Appendix B). While much regarding this issue is well documented, the literature research was supplemented with interviews of engineers and other stakeholders and by other outreach methods. This outreach provided up-to-date assessments of the barriers and their significance and began to engage the project's intended audiences and to lay the foundation for future change.

This project focused on the barriers to engineers giving equitable evaluation to decentralized wastewater treatment, not the broader question of barriers to decentralized wastewater treatment itself. The distinction is subtle and may be difficult to communicate to people who have a high degree of frustration with the status quo. The literature review, interviews, and other outreach alternated between the broader question of barriers to decentralized wastewater treatment and the narrower question of barriers to engineers equitably considering decentralized options. Answers to both questions gave input useful to the narrower question of equitable consideration.

The purpose of Phase I of this project was to efficiently identify barriers so that ways to overcome the most significant ones could be developed in Phase II. Thus, accurate identification of barriers or perceived barriers was prioritized over referencing specific articles or interviewees responsible for earliest enunciation of each barrier. The team endeavored to give credit to the many people whose spoken and written words informed this work. However, individuals were generally only given specific credit for discussing a barrier when a direct quote was used to illustrate or explain a barrier.

Project activities are described below in approximately the order they occurred, although there was some overlap between activities. The literature review continued as the interviews began, for example, and a preliminary classification of the barriers was made before interviews began.

A.1.1 Literature Review

Relevant literature was reviewed for identification of barriers to decentralized wastewater treatment; relatively little was found on barriers to engineers giving equitable consideration to decentralized wastewater treatment. Chapter 4 of the U.S. EPA's 1997 report, *Response to Congress on use of decentralized wastewater treatment systems* (U.S. EPA 1997), is perhaps the most thorough previous overview of the barriers to decentralized wastewater treatment. Other reports and articles consulted are described in Appendix B.

A.1.2 Professional Experience

The project team's experience working with decentralized wastewater treatment projects was used to add to and refine the list of barriers, particularly in the project's inception.

A.1.3 Interviews and Other Outreach

Interviews and other forms of conversation with stakeholders were used to add to the barriers found in the literature and to provide concrete examples.

A.1.3.1 Project Subcommittee Input

The WERF Project Manager was advised by a Project Subcommittee (PSC) who helped define the project and provided periodic input and feedback on its progress. At an initial meeting, the PSC and the WERF project manager gave input on project barriers. The barriers identified added significantly to the list identified through the literature review.

A.1.3.2 In-depth Interviews with Stakeholders

Four project team members conducted in-depth interviews of key stakeholders to supplement the lists of barriers gathered from the literature review and the PSC input. Engineers comprised the largest single category of people interviewed, but representatives of numerous other categories were also included (See Table A-). Individuals representing positive case studies, i.e., cases where equitable evaluation of centralized and decentralized alternatives had taken place, were also interviewed to learn about the barriers they faced and to determine other possible roles for their cases in Phase II of the project.

Table A-1. Interviews by Sector

Sector	Number of Interviews
Engineering Firms	9
Financial Institutions	2
Communities / Utilities	3
Academic Programs	4
EPA	1
Other Regulators	1
Development Community	1
Environmental Community	2
Other	2
Total	25

The interviews were conducted as qualitative interviews. A study design document that outlined the process for the four interviewers was drawn from primarily from (Rubin and Rubin, 2005). The model used for the interviews is called "responsive interviewing", emphasizing that the direction of the interview and thus of the project emerge in the interaction between the interviewer and interviewee. The interviewers were encouraged to keep in mind that "*[q]ualitative research is not simply learning about a topic, but also learning what is important to those being studied*" (Rubin and Rubin, 2005 emphasis in original). A list of interviewees is shown in Table A-2.

Table A-2. Interviewees' Names and Affiliations.

Interviewee	Sector	Affiliation
Bob Baglini	Engineering firm	BETA Group
David Venhuizen	Engineering firm	Independent engineer
George Nolte	Engineering firm	Nolte Associates
Greg Goodman	Engineering firm	Camp Dresser & McKee, Inc.
Mark Adams	Engineering firm	NorthStar Engineering
Sue Parten	Engineering firm	Community Environmental Services
Dick Otis	Engineering firm	Ayres Associates
Harold Baker	Engineering firm	Volkert & Associates Inc.
Joe Federico	Engineering firm	BETA Group
Jeff Hughes	Financial institution	University of North Carolina's Environmental Finance Center
Richard Rose	Financial institution	New Mexico Environment Department, Construction Programs Bureau
Ed Clerico	Community/Utility	(Formerly) E'town Water
Crespin Guzman	Community/Utility	(Formerly) Austin Water Utility
Jack Miniclier	Community/Utility	Charles City County (Virginia) Public Works & Utilities
Jim Converse	Academic Program	University of Wisconsin–Madison
Kitt Farrell-Poe	Academic Program	University of Arizona
Bruce Lesikar	(joint interview)	Texas A&M University
George Loomis		University of Rhode Island
Jerry Stonebridge		Water Wastewater Maintenance Management Specialists
Dave Gustafson	Academic Program	University of Minnesota
Chuck Johnson	Academic Program	(Formerly) University of Wisconsin–Madison (student)
Joyce Hudson	EPA	U.S. EPA, Office of Water
Ron Dykstra	Regulator	Central Valley Regional Water Board (California)
Neil Strawser	Development community	Landpro Development Corporation (Ohio)
Nancy Stoner	Environmental community	Natural Resources Defense Council
Bob Zimmerman	Environmental community	Charles River Watershed Association
David Dow	Other (Onsite service provider)	Onsite Collaborative, LLC
Don Schwartz	Other (Community service provider)	Rural Community Assistance Program

A.1.3.3 Forum at a National Conference

A 90-minute forum was held as a parallel session at the annual NOWRA (National Onsite Wastewater Recycling Association) conference in Cleveland, Ohio in October 2004. Approximately 40 conference participants attended. The forum included an overview of the project, the preliminary results of barriers identification, and an opportunity for audience members to identify additional barriers and to suggest ways to overcome them. Audience members were also encouraged to write down their thoughts about what the barriers are and how to overcome them. These papers were collected and the ideas were used to expand the lists of barriers.

A.1.3.4 Workshop at Orenco Systems Inc., Sutherlin, Oregon

The first task of the project entailed identifying the most important factors which affect whether engineers equitably consider decentralized wastewater treatment options. In December 2005, the draft report for Task 1 of this project, entitled "Identification of Barriers to

Decentralized Systems within the Engineering Community" was made available to WERF subscribers as well as to others in the decentralized community. This review resulted in some helpful suggestions to the project, along with some good opportunities. One such opportunity was an offer from Orenco Systems, Inc. (OSI; via Hal Ball, President) to provide their services and host a one-day forum to supplement this project's work-to-date and to generate ideas at their headquarters in Sutherlin, Oregon.

The purpose of the meeting was to both give the perspective of some of the leading manufacturers' engineers in the field and to provide the face-to-face exchanges which would boost creativity and wisdom of the group. The meeting would also help build "champions" for the project's findings, which has been a fundamental goal of the project and a suggestion of the PSC. The forum was held on August 24, 2006, at about the same time the project team is receiving feedback from the Project Subcommittee and the SSC on the first round of ideas for overcoming barriers. The project team used the results of this forum as additional input into the final report.

The following participants attended the forum:

- Hal Ball, Terry Bounds, Mark Gross, Bill Caigle, Grant Denn, Sam Carter, and Jeff Ball, Orenco Systems Inc.
- PSC member Robert Rubin
- Carl Etnier, Stone Environmental, Inc.

A.1.4 Classification and Assessment of Significance

The project team classified the barriers found during the literature search into four categories using an influence diagram that was constructed to show how each barrier relates to the others (see APPENDIX C). The influence diagram showed how each barrier affects the probability that engineers will equitably consider decentralized systems.

The four initial categories of barriers were:

- Engineers' financial reward for using centralized systems
- Engineers' lack of knowledge of decentralized systems
- Engineers' unfavorable perception of decentralized systems
- Unfavorability of the regulatory system for decentralized systems

Additional barriers identified through conversation with the PSC led to the creation of a fifth category:

- Lack of systems thinking applied to wastewater issues

All subsequently identified barriers were included in these five categories.

Assessing Significance

The list of barriers generated through all these methods was long and difficult to condense. Classifying the barriers into categories helped and resulted in five somewhat shorter lists. To conclude Phase I and move towards prioritizing and finding ways to overcome the barriers, the significance of the various barriers was briefly considered. Two methods were used:

- Listening to the interviewees. Most interviewees were asked, toward the end of the interview, which barrier or barriers they perceived to be most significant and these answers were compiled.
- Themes from the interviews and perspectives of the project team. Once the literature search and the interview process was complete, the project team had access to a wide variety of perspectives on barriers. The team considered these perceptions and constructed a list of key themes. The themes were tentative conclusions on the types of barriers that were most important.

A.2 Phase 2: Overcoming the Barriers

In the second phase of this project, the team identified and prioritized ways to overcome the barriers. The first step was to identify which of the barriers and barrier categories were most influential.

A.2.1 Prioritize Barriers and Barrier Categories

The tentative conclusions about the significance of barriers reached at the end of Phase 1 were re-visited with more formal tools at the beginning of Phase 2. A method was used to find the most *influential* barriers. The most influential barriers are not necessarily the ones that people bump up against most often, or which have the greatest effect on decisions—though they may be. The influential barriers are the ones that have both a direct effect on blocking equitable consideration of decentralized wastewater treatment and which affect other barriers. For example, Barrier X may be one that engineers meet up with every day, but Barrier Y is more influential if Barrier X cannot be overcome without removing Barrier Y first.

The interrelationship digraph method described in Appendix C was used to assess the relative influence of the barriers within each category and of the five barrier categories identified. Five members of the project team participated in multiple teleconferences to apply this method. At the conclusion of the exercise, four barrier categories were identified as most influential, and the number of barriers remaining in each category was considerably reduced. The most influential barriers and barrier categories, as well as illustrations of them, are in Appendix D.

A.2.2 Identify Potential Strategies and Actions by Barrier

The project team brainstormed potential strategies and actions that engineers could accomplish to overcome each influential barrier. A blank table was created, with columns corresponding to types of engineers (consulting engineers, regulatory & other public sector engineers, community/utility engineers, university engineers (teachers, researchers), manufacturers' engineers, and engineering societies and other organizations). The rows represented each strategy. First individually and then in teleconferences, project team members filled in the cells of the table with strategies and actions that that particular type of engineer could apply to each barrier.

A.2.3 Prioritize Strategies and Actions

Prioritizing requires judgment. The project team welcomed collaboration of others in applying professional judgment to the prioritization. From the ranks of people interviewed in Phase I and others, the project team invited people to join a Stakeholder Sounding Committee to comment on the team's prioritization and assist in further developing the ideas. Committee members were both polled formally (as described below) and contacted for ideas and information as needed. Following is a list of the Stakeholder Sounding Committee members and their affiliations.

Name	Affiliation
Mark Adams	NorthStar Engineering
David Casaletto	Table Rock Lake Water Quality
Ed Clerico	Alliance Environmental
Kitt Farrell-Poe	University of Arizona
Joe Federico	BETA Group
Rod Frederick	U.S. EPA
Simon Gruber	Orange County Water Authority
Lisa Hajjar	Dept. of Health & Environmental Control - Office of Coastal Resource Management
Richard (Dick) Otis	Ayres Associates
Richard Rose	New Mexico Environment Department, Construction Programs Bureau
Don Schwartz	Rural Community Assistance Program
Jerry Stonebridge	Water Wastewater Maintenance Management Specialists
Nancy Stoner	Natural Resources Defense Council
Dennis Tulang	Former Manager, Hawaii Dept. of Health Wastewater Branch. Now with Metcalf & Eddy Pacific.
David Venhuizen	independent engineer
Kevin White	Dept. of Civil Engineering, Univ. of South Alabama
Bob Zimmerman	Charles River Watershed Association

The project team began prioritizing the brainstormed strategies and actions through the "dot voting" method, in which each team member was given 25 points to distribute among the strategies and actions in each row—that is, corresponding to each barrier. While examining the voting results, the team used further discussion to remove some strategies and actions and to consolidate and improve others.

Each strategy was then linked with one or more actions, and a document was created to show how each strategy and set of actions addressed the influential barriers. This document, along with a scoring and comments sheet, was sent to members of the Stakeholder Sounding Committee, the WERF project manager, and the WERF Project Subcommittee (PSC) for assessment and comments.

While the comments and assessments were coming in, a member of the project team held a day-long meeting with a member of the PSC and many members of decentralized wastewater component manufacturing industry at the headquarters of Orenco Systems, Inc. to collect their views on the most effective ways to overcome barriers.

Using the comments and assessments received to help identify the most effective strategy and actions, the project team narrowed the number of strategies and actions in each barrier category to a number which could be addressed in detail.

A.2.4 Develop Strategies and Actions

The prioritized strategies and actions were further developed by team members. Additional research was conducted to learn what resources are already available, whether similar actions had been tried by others, which organizations are available to carry out the actions, etc. Each action was also reviewed for possible unintended consequences, including those for other water and environmental programs, fiscal implications, and regulatory implications. The resulting strategies and actions were described in this report and submitted to the WERF project manager and PSC for review and comment.

APPENDIX B

LITERATURE SEARCH

Chapter 4 of the U.S. EPA's 1997 report, *Response to Congress on use of decentralized wastewater treatment systems*, was an excellent starting point in the search for barriers.

A search for articles was made using Agricola, Lexis/Nexis Academic Universe, Web of Knowledge (formerly Science Citation Index and Social Science Citation Index), and Ei Compendex (the electronic equivalent of the Engineering Index), with search terms such as (for the Web of Knowledge):

(ti=decentralized OR ti=onsite OR ti=on-site OR ti=septic) AND (ti=barrier OR ti=obstacle OR ti=decision OR ti=econom* OR ti=engineer*)

The search turned up few useful results. The *Response to Congress on use of decentralized wastewater treatment systems* was not among the reports that one could search for in articles' citation lists.

The following reports from the National Decentralized Water Resources Capacity Development Project were evaluated:

- Pinkham, R. D., J. Magliaro, and M. Kinsley. 2004. Case Studies of Economic Analysis and Community Decision Making for Decentralized Wastewater Systems. Project No. WU-HT-02-03.
- McKee, R. J. and S. McNulty. 2003. Evaluating Customer Response to Decentralized Wastewater Treatment Options. Project No. WU-HT-02-35.
- Onsite Wastewater Issue Papers Delivered to U.S. EPA by the State Regulators and Captains of Industry. April 20, 2001. Washington D.C.
- Advanced On-Site Wastewater Treatment and Management Market Study; Volume 1: Assessment of Short-Term Opportunities and Long-Run Potential; Volume 2: State Reports. Report No. 1000612. Date Published: Sep 2000.

No research relevant to identifying barriers was found in WERF's library of reports.

A Yahoo! Internet search using the terms the terms "innovative technology barriers wastewater" returned the following:

- Innovative Technologies for Wastewater Pollution Control and Prevention: Barriers, Incentives and Barrier Solutions. (The report was apparently written for the U.S. EPA by the Rensselaerville Institute around 1997. It focuses on innovative technologies for centralized wastewater treatment, but some of the barriers identified are relevant to this study. The document includes case studies, critical incidents, interviews with stakeholders, and use of focus groups.)
- Testimony Of David Gardiner, Assistant Administrator For Policy, Planning & Evaluation, U.S. Environmental Protection Agency, Before The Subcommittee On Technology And The Subcommittee On Energy And Environment Of The Committee On Science House Of

Representatives. June 20, 1996. On promoting innovative environmental technology in general, with one wastewater project mentioned. (This document contains information similar to that in the Response to Congress and the Rensselaerville Institute report.)

- Social Experiments in Innovative Environmental Management: The emergence of ecotechnology. Gregory David Rose. A thesis presented to the University of Waterloo in fulfillment of the thesis requirement for the degree of Doctor of Philosophy in Planning. Waterloo, Ontario, Canada, 2003. "Ecotechnologies" examined are constructed wetlands and greenhouse systems for wastewater treatment. "The overall objective of the research was to identify key factors both driving and constraining the adoption and implementation of the ecotechnology across four case studies."

Other sources consulted included:

- Aiton, M., J. Hoornbeek, and S. Fallon. 1994. Training needs to know and implications for small community wastewater professionals. In Seventh international symposium on individual and small community sewage systems, edited by E. Collins. Atlanta, Georgia: American Society of Agricultural Engineers.
- Jantrania, Anish R., W.M. Robertson, and E.F. Katz. 1998. Installing I/A systems in a community for the first time: Lessons learned from Gloucester, Massachusetts project. In Eighth national symposium on individual and small community sewage systems, edited by D. M. Sievers. Orlando, Florida: American Society of Agricultural Engineers.
- Mancl, Karen, Bruce Forintos, Jackie Sticha, Charles Johnson, P. Liepold, H.B. Calvert, and Bill Leonard. 1998. Working effectively with small communities: An educational program for consulting engineers. In Eighth national symposium on individual and small community sewage systems, edited by D. M. Sievers. Orlando, Florida: American Society of Agricultural Engineers.

APPENDIX C

INTERRELATIONSHIP DIGRAPHS OF BARRIER CATEGORIES

At the close of Phase I of this project, the barriers had been classified into one of five categories. Early in Phase II, the significance of these barriers was evaluated using interrelationship digraphs. An interrelationship digraph is a graphical, qualitative analysis method that is focused towards finding root causes or drivers.

An interrelationship digraph is produced by writing the identified factors on a paper in random positions. Starting with one of the factors, an arrow is drawn from that factor to each of the other items it affects. The directionality of the arrow shows the direction that the main influence moves in. If two items seem to influence each other, the predominant influence is drawn. The process is continued for each of the other factors. Once arrows have been drawn for all the factors, the number of arrows pointing towards or away from each factor is noted. Analysis then shows which of the factors are the most influential.

The interrelationship digraph method was applied by the project team jointly, at the level of each of the five categories of barriers and at the top level of the five barrier categories, for a total of six digraphs. The top-level digraph is shown in
Figure C-1 below.

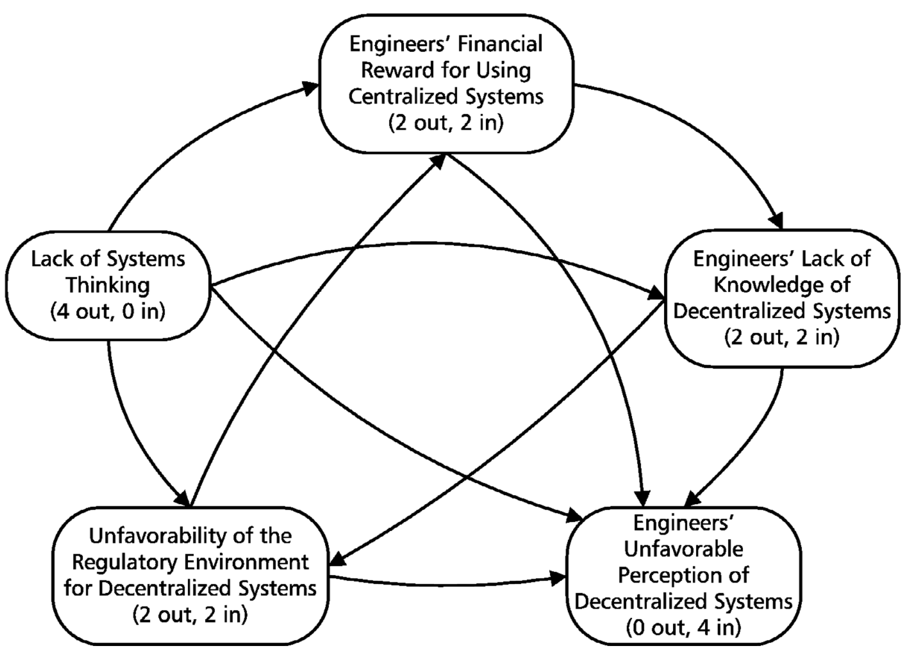

Figure C-1. Interrelationship Digraph Showing the Relationships between Barrier Categories.

For the example shown above, the digraph was created on the question, “Which category of barriers represents the greatest obstacle to equitable consideration of decentralized systems?” The project team completed the digraph to identify a strategic “driver” to focus on. The box with the most “out” arrows identified “lack of systems thinking” as the strategic driver. The ranking that resulted from the digraph discussions provided the project team with the means to focus attention on areas with the greatest opportunity to produce meaningful change.

APPENDIX D

COMPLETE TABLES OF MOST SIGNIFICANT BARRIERS

Table D-1. Barriers Related to Engineers' Financial Reward for Using Centralized Systems.

Barrier Category: Engineers' Financial Reward for Using Centralized Systems	
Barriers and Opportunities	**Explanations, Examples, and Exceptions**
Demand Issues	
Few funding programs require thorough consideration of decentralized options	*Some funding guidelines require consideration of decentralized, but they may not be taken seriously:* Rural Utilities Service (RUS) bulletin 1780-3 gives an outline of what a Preliminary Engineering Report (PER) is to address. It specifically mentions that onsite solutions need to be considered. So when a community puts an RFP (request for proposal) together, they must state explicitly that the consultant must follow RUS guidelines. This sets consultants on notice that they need to do that. So a PER has definite meaning. … Traditionally engineers are more comfortable with gravity sewers, manholes, and activated sludge plants with a 20-year design life. It is a challenge to them to take a serious look at decentralized options. Initially we got one sentence saying decentralized is not acceptable. Now it's our position that if we are paying for a study, we want a product that addresses all the issues. We won't force you to do something, but if the product [the PER] does not meet our needs, we won't pay for it.
Attitudes of regulators and municipalities do not support or help create demand for decentralized systems.	*Engineers respond to demand:* The engineers fill a need. Until there is a need for large-scale onsite projects—demanded by regulators and asked for by municipalities—the engineering community is not going to go in that direction. … The most important barrier is the regulatory community, because of the chicken and egg thing. If regulators will not accept it, and won't be creative, then engineers aren't going to design it. If getting decentralized permitted is more work for engineers, they aren't going to do it. And municipalities will not ask for it if they know it will be a battle.
	Engineers are caught in the middle between the client's best interest and what regulators will permit: An engineering firm will do what a municipality tells it to do. If the municipality doesn't want them to look at alternatives, they won't, even though that's in the municipality's best interest. And the municipality might not want to fight the regulator. The engineer is caught in the middle.
Developers just want what is easy and cheap	*Developers just want to get a permit as easily as possible:* I think the development community is looking for streamlining of permitting. If it's [decentralized] the only thing to allow development, then they're willing to look. … They want to do it as easily as possible. The only way these guys do anything innovative is because they have to. They are looking at the bottom line. It's just a matter of "is this going to get me the development permit?"
	Developers may want systems that don't match a utility's needs: You need to make sure they [developers installing infrastructure] are standardizing on certain systems. That is difficult. Developers have an idea what they want to do, but if you want them to turn over the infrastructure to the county system, it must be of one kind. You don't want different pumps and so on. You want to minimize personnel, what it takes to operate.
	"Time is money" works against advanced systems: I'm not seeing a lot more contractors coming out being willing to jump into it [advanced decentralized systems]. It's not the slam 'em in thing. One good contractor we have worked with over the years says it takes a week to 2 weeks for a sand filter versus doing a standard septic in a day.
	Development approvals can be used to demand better systems: Developers are interested in the least money upfront. The way our program has sometimes gotten into the door of developer is that often times, at certain points of negotiation in terms of the type of

Barrier Category: Engineers' Financial Reward for Using Centralized Systems	
Barriers and Opportunities	**Explanations, Examples, and Exceptions**
	infrastructure, the developer may need to meet certain standards.
	Developers don't like the land requirements of decentralized systems: Overall, I don't believe the backing [for a decentralized program] was there from developers due to the land requirements. You need a certain area per unit for a common disposal area. Developers would say "You're not leaving us enough land to develop to be profitable."
	The private sector is least-cost oriented: Public sector leadership is needed to establish equitable consideration.
	We need to use development approvals to demand better systems: Developers are interested in the least money upfront and can be required to consider decentralized equitably.
Decentralized systems are seen as atypical or "second rate"	*Developers don't want to do anything different that might harm marketability:* That [the difference in the physical system—how it looks, etc.] is a marketing liability with builders. People are used to doing things a certain way, and think if they deviate, they are likely to get sued. There is a herd mentality to do what has traditionally been done, because they don't want people who buy the lots to say this not what we are used to seeing.
	The public perception is that decentralized systems are second rate, compared to sewers: When annexing around the city, and the city utility will be the service provider, the public to be served often looks at decentralized as a second-rate solution. They think, if now I'm in the city, then give me sewer, and so are not inclined to pay the same wastewater rate. So, over the years we have encouraged differential rate structures to give the public a reason to go there [decentralized]. The utility has not been so inclined.
Clients and the public do not have sufficient knowledge of decentralized options and their characteristics to request engineers to consider them.	*The field needs success stories small towns can relate to and verify themselves:* I'd love to go to a community tomorrow and say here's what they did in [community 1] and [community 2] and [community 3], and it works—don't believe me, call the town supervisors there. I'm waiting for a few success stories, so we can put together information on the positives and negatives, and give them names and phone numbers. Lack of proven success is a barrier.
	Lack of information flow in community hinders consideration of options: I've made three presentations out there [a particular community] in the last three months on onsite options. In each case, it was a different audience. They all say we didn't know these options were available. The problem is, there are different city councilors, and city administrators, over time. It's different people in the same place, and still the jury is out on what will the community do. … And the report didn't receive general distribution. Even if you do a Preliminary Engineering Report and give it to the city administrator or council, that doesn't insure general distribution.
	Case studies need to filter down to local health departments and local planning commissions, too.
	Adequate education of all players is important: This [problem] went to the importance of general education and understanding. You have to look at the general understanding and education of owners as well as regulators. That was the initial effort, to educate people. We thought pilots and demonstrations would do this. We had great plans that never really materialized.
	There is a tipping point. You have to get to that, to someone being willing to try it, then pretty soon everyone understands.
Decentralized solutions are seen as incomplete or too costly, or difficult to construct well	*Lack of integrated manufactured systems has been a barrier, but that is changing:* You can get a good Preliminary Engineering Report with bid specs, then go out to industry. I had a series of bid sheets for components, and including maintenance costs. I didn't say specifically I wanted 16,000 feet of drip line. I think we are starting to see more small manufacturers doing turnkey systems. Each guy was doing some components by himself. Now one is offering all parts of the system.
	Treatment systems are becoming standardized, but dispersal remains more customized

Barrier Category: Engineers' Financial Reward for Using Centralized Systems	
Barriers and Opportunities	**Explanations, Examples, and Exceptions**
	and difficult: When I put out the Preliminary Engineering Report I didn't care if treatment was a filter system or aeration plant. We put it out performance-based; we did not say what type of system. If you're talking a three thousand gallon plant, the industry today—from Orenco to peat systems to many small aeration units—builds these plants the same every time. Maybe there's more alarms on one. The difficulty is always the dispersal.
	Builders and developers think some systems required by regulations are too expensive and hard to build: Builders haven't had to get engineers in the past. They use companies that just do onsite systems—installers. They have to do a plan and submit it to the board of health to get a permit. I hear complaints about the price of mound systems. And that they're difficult to build—just a pain. From what I understand, they don't work that well, either. … We have steered away from [particular] County. They have been almost categorically for mounds. We don't like that. They cost close to $20,000 versus $8,500 for a standard septic system or aerobic units for $9,000 to $10,000. They're unsightly and work less well.
	Staffing costs are very important for small or low income communities, but can be compensated for with operational automation: The other piece on cost to folks is with operator time there. I promised to the board of supervisors not to add more staff with these three systems. This was partly accomplished through automation. … Having the ability to monitor and operate from off-site is critical. Manpower is a key cost.
	Centralized has lower operation and maintenance labor costs: Centralized systems can be operated and maintained with less labor (man-hours per unit volume treated). In [European country], labor is very costly compared to capital costs, energy, chemicals, etc. This makes centralized more economically reasonable and is a very heavy factor for even more centralized.
	The wastewater industry is way behind in cost-saving monitoring and telemetry: A guy who works for me was in HVAC. The wastewater industry is antique in sending and using data. The HVAC industry can run a building based on those readings. The question is what is a regulator going to do with all this stuff? I was all for it [getting the operating/monitoring data] because I wanted my operator to control the process and to know he doesn't have to go out there to do it.
Clients do not see the added value decentralized can provide (e.g., avoiding the financial commitments of centralized capacity, preserving community character)	*We need to demonstrate the advantages of decentralized to different audiences.* To local officials: manage (promote or limit) growth. To the community: protect investments in infrastructure. To regulators: protect health.
	Decentralized allows market entry for some businesses: Some commercial enterprises—like fast food and grocery stores—have discovered they can get into unsewered communities. That limits development but lowers land cost. They have to spend more for an onsite system, but it allows them to get into the community.
	Population growth affects capacity and incremental capacity expansion favors decentralized: Everything else is based on the size of the population, like tank size. So we pay particular attention to where a proposed project is from. Recently we looked at [a facilities plan]—the plan had a three percent growth rate, yet the census showed a decline over the last 10 years. We raised that question with the consultant. You don't want to undersize, but you don't want overcapacity. … Fear of growth is one factor in discussion of onsite alternatives, which are usually more modular, so it's easier to add on as you grow as opposed to an activated sludge plant, which is sized for buildout, and the existing population is burdened with the cost.
	Preservation of community character can be a driver for avoiding sewers: The fear of changing the character of a community by addressing the wastewater needs with sewers is real. Educating community leaders that a decentralized approach can resolve public health or water quality problems without changing the nature and character of the neighborhood or community is a challenge. Developers have found their way around zoning restrictions, so often the avoidance of sewers is seen as a way to preserve the cherished character of a

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Barriers and Opportunities	Explanations, Examples, and Exceptions
	community.
	Engineers don't communicate the options: Communities that are scared of sewer because they know it will change the character of their community don't even talk with engineers to find out that there are other options. Therefore the barrier is lack of information and communication that there are other options. Engineers don't talk to communities or their leaders for free. They have to have billable hours.
	Increased density and green building are drivers for decentralized: Some drivers are, first, lack of regional infrastructure, yet the desire to build something on a scale or density that would preclude individual septics. Like it's a problem if you put too many septics in one group, for example for nitrogen dilution. Or second, the green building approach—people want to do something on an environmentally sensitive basis.
	Decentralized systems can perform as well as centralized ones: I don't think anyone would have an issue with that [a system's performance]. These systems seem to run very well. The removal efficiencies are high.
The public does not understand and support management of decentralized systems	*It's difficult to demonstrate the need for management costs:* I am happy to see the USDA Rural Utility Service is moving to an asset management approach. We're looking at ways to incorporate that into funding—ways to make operations funding sustainable. Problem is, people think, "Septic tanks didn't cost anything yesterday, and now are $10 per month, what's going on?" It's a harder concept to sell since people see less benefits [vs. centralized, where utility comes out to fix sewers].
	Average people that don't know options, don't understand why the cost is needed: Knowledge [of decentralized systems] is very little, with the exception of a very few people. "I flush the toilet and it goes away." They don't want to pay a water bill or a sewer bill or other services. Many people I work with have never paid a sewer or water bill in their lives. You start talking about even a $30 water bill, let alone $90? They don't pump their tank for 30 years and don't want to.
	Lack of public awareness of decentralized options and of the need for improved wastewater management is a barrier: People are not aware, so it doesn't get considered. … In [community] they have been doing Preliminary Engineering Report for 3 years, and we are still trying to get them to monitor ground water. They say they are not aware of any problems, so why do anything?
	Political timidity vis-à-vis management is not necessary: I think people are so willing to accept maintenance. If you manage septic for 300 dollars and guarantee it will never fail, people are willing to pay [when they see people paying more for sewers]. People are so politically timid. If they could get over the initial political shock/hurdle, within a generation it's an accepted fact.
Local governments and publics are leery of government involvement in decentralized systems (e.g., for management)	*Potential government involvement for decentralized scares people, especially town leaders:* People live in rural areas because they don't want to deal with the government. The municipal officials in these areas are no different than anyone else. They think, "Oh my gosh, I'm going to have to go on my brother's land and tell him to pump his septic tank." Or to tell him that we'll take his land by eminent domain to connect 3 homes to a drainfield there. The combinations or permutations of negative interactions are immense in their minds. They're going to get enormously involved in people's lives when the only involvement they've had in the past is in plowing their roads in the winter. It scares them to death. But what scares them worse is a $93 [monthly] sewer bill. Communities are often stuck between two unfavorable options—involvement in residents' property and lives, or paying a whole lot more for a centralized system that minimizes that.
	Decentralized involves government in people's privacy: When you get to decentralized, you might have 5 people on a sand filter, some people on on-lot systems, others on a discharge system to a creek. The township still has to manage those systems. It involves coming onto people's private property. Maybe the township owns the system in someone's back yard. It

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Barriers and Opportunities	**Explanations, Examples, and Exceptions**
	involves direct contact with your neighbors in a very personal way with their wastewater, instead of a plant that no one sees.
	Communities don't want the government activity that management of decentralized requires: It's hard to get [particular] village to say it will be a management agency. The councilors don't want more government. An option is to run a big pipe to [city], let them take care of it. The counterpoint is the neighborhood association is shocked, because then people will have no voice, especially in fees. They have no representative on the city council, so they see this as an abdication of authority. … And the government side [is an issue]. [Village] doesn't want to start a public works department. Many rural communities are not anxious to expand government.
Financial institutions that fund wastewater projects prefer to deal with municipalities, not individual homeowners, and municipalities may not be prepared to assume financial responsibility for onsite systems.	*Communities can use their tax powers to guarantee loans, but are reluctant to do so:* The funders are coming around and accept decentralized. I've been assured by USDA and [a state financing agency] that they will accept a decentralized approach, as long as it fits their guidelines. Municipalities pledge their taxing power (in lieu of a mortgage on a treatment plant) to pay back the loan. Here we have townships, the next level down from a county. A township has some villages and some land. One village with 100-200 homes needs a sewage system. They go to the government for funding. They say they'll give a couple million dollars, but the government wants a pledge so they'll get their money back, even if people don't pay their sewer bills. If people don't pay the bills, a judge can issue an order to raise everyone's taxes. And imagine if 90% of the people aren't served by the sewer! …Imagine if their neighbors have to pay for it, if they don't pay their bills. It scares them [community leaders] to death.
	Financing agencies would be more willing to lend money for onsite systems if towns take financial responsibility: I think more grants would be available for onsite if the municipal authorities were willing to take responsibility for repayment. For example, my state, through [the state's revolving loan fund] works with the housing authority to offer low-interest loans to homeowners. Then towns are on the hook for the money if the homeowners default, because the town can put tax liens on property. They could in fact confiscate property if tax liabilities are not paid. Because the town is willing to stick its neck out, the financial institution is willing to lend money for onsite systems. Towns do this [put liens on property] all the time. [The decentralized field] could be more creative, like that. There's not much demand for it now because of low interest rates, and people can easily get home equity lines of credit. But if money should become tighter, or the real estate bubble burst… [it would be an issue].
Small communities need technical and managerial assistance	*Communities need help in implementation and startup of wastewater systems:* In [state], we work a lot [to help communities] on implementation and startup. The government (state or federal) will give a community the money to build a sewage treatment system. It's like giving a 16-year+ old kid keys to a nice car and walking away. How do we hire an operator? How do we hold a board meeting? What do we do when the first 50 people don't pay their bills? So, financial, managerial, and technical capacity are important.
	Make sure it's something easy to operate.
Strong fiscal pressures exist to increase the number of connections to existing centralized systems, which discourages municipalities from working with decentralized systems.	*There is pressure to increase the number of connections to centralized [to pay for the system].*
Funding Availability and Conditions	
Funding is more available	*Funding is there for centralized:* Engineers are comfortable doing centralized systems. The

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Barriers and Opportunities	Explanations, Examples, and Exceptions
for centralized	funding is there for centralized solutions. Nearly all of the special "add-on" congressionally mandated grants are for centralized systems. *The lack of availability of public financing for decentralized system planning and construction is a problem.* *The field needs to overcome limited availability of public financing for decentralized system planning and construction:* Use set asides and directives for various small projects. And not just for wastewater; also for low impact development and other things that are small, discrete projects. … But this sometimes doesn't work very well. Language from Congress has not been mandatory language, and EPA says "We don't have to do it." … There are not a lot of mandatory set-asides in state revolving loan funds (SRFs). *Funding program "biases" depend on program objectives, which differ widely:* The first thing [about funding programs] is there are some strings—some type of environmental or public health objectives. Beyond that are a whole host of restrictions and limitations—who can be funded, what types of facilities. SRFs are very different from USDA Rural Utilities Service funding. Those are the two big programs. With respect to the SRF, it is oriented to water pollution prevention objectives—they must trace [funded projects] back to clean water objectives of having a measurable impact on the nation's water. So, it has primarily environmental objectives. In contrast are USDA programs, which are within the historical Farmer's Home Administration. They may have an environmental aspect but they are more concerned with rural development, and the [financial] health of the community. So the SRF is much more interested in treatment facilities with direct impacts on effluent, to help communities meet NPDES requirements. USDA is more open to a new sewer line to people unserved by sewer. There's a stark difference, to the point where some SRFs won't fund service extensions—they might lead to growth or possibly worse pollution. *The funding focus is on centralized:* [State], over the last 10 years, has invested close to one billion dollars in water and wastewater projects. It's been a big push. Of those [projects], the vast majority of programs and funds go to centralized. It's similar to some of the federal programs, which are also much more oriented toward centralized. *Some funders see addressing onsite systems as an untapped chance to make a difference:* One state program is in part selling itself on surface water and groundwater quality. It is much more open to decentralized. It is the Clean Water Management Trust Fund. It is the biggest source [in interviewee's state] for septic repair and straight pipe elimination. [This is because] they are oriented to pollution reduction projects. Fifty percent of state residents are on septics. It is an accepted source of nonpoint pollution. The funder sees serving this group as an untapped way to make a difference. They are also concerned about secondary impacts of wastewater projects. They have on several occasions turned around on a proposal for sewer, and said let's look at decentralized and not create all the environmental stress with centralized. They promote not necessarily new development on septics, but if a community can figure out a financial way to stay on decentralized, that keeps density down. That's in some cases the primary environmental benefit. So the program staff say let's not shoot ourselves in the foot [by funding a sewer project] and end up with malls and parking lots—ultimately the environmental quality could be worse. *It would help to have financial support for preliminary engineering studies.* *There are barriers inherent in the SRF program (both at state and federal levels) to using funds for decentralized.*
Homeowners prefer private ownership, but funding agencies prefer public ownership	*Municipalities prefer public ownership; homeowners and banks prefer private ownership:* Traditionally, when you get bond money, it is for equipment and things that are publicly owned. Unless it's a community system with common treatment, most homeowners would prefer to own their septic system. I think traditionally people want to. If municipal, their bonding is through a financial institution, which is more comfortable if the system is publicly owned. Banks more likely to finance onsite systems for individuals, especially given equity

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	in property the way it is now. The banks have been pretty good; they are giving home equity loans for onsite.
The lack of financial viability of centralized for many communities is not universally recognized	*The expense of centralized and lack of money is beginning to drive change:* We've reached a point in [state] where trying to find a cost-effective wastewater treatment solution is extremely difficult. … I was speaking to someone in [particular] County yesterday and they're going to the SRF for a big project. The best guess is that they will have a $93 per month sewer bill. … [The regulatory push for centralized] is starting to change when you're looking at $93 per month sewer bills. What's driving this all is money. When I started in the early 1990s the average sewer bill was $21 per month, or so. Now the average bill on new projects is $50-60 per month. And the median gross household income is $30-35K/year. … Most places other than very small communities—a couple hundred homes or less—are already sewered. Funding agencies are being swamped with [small community] applications and there is very little grant money. … What's driving this thing is money. There's not enough money to have a centralized system for everybody at a reasonable price.
Funding agencies lack familiarity and experience with decentralized	*Funding agency familiarity/experience with decentralized is important and increasing:* So having done that, for us, being involved with four agencies, discussing commonalities—the agencies are familiar with the concept, and have funded it. … Other funding agencies are not pushing decentralized aggressively, but if comes up, there is not a "what is this?" reaction.
Use of public money on private land is legally and administratively problematic.	*Paying for private property, and liability, limits municipal creativity to solve wastewater problems:* Municipal people are worried about offering funding for privately owned septics. What I've found, even through [university], is that communities are unbelievably paranoid about liability—equipment, walking over peoples' property, anything. *Investment of public money in private property is problematic for funders:* The other huge difference in perception is the difference between private versus public assets. From local to even federal funding, there are small or large hurdles on who can be a recipient of funds. With a sewer line, it is understood it is public property. For the same number of failing systems, you might invest half as much to upgrade [septics rather than build sewer], but that is by many definitions an investment on private property, a private asset. *Solutions to the problem of investing public money on private property involve more effort for public programs on things that aren't the focus of the effort:* Places have gotten around this [using public funds on private property] with easements so that the local government has some jurisdiction. Then we're back to how it's [decentralized] onerous for local government, a significant barrier. Some programs have had to be creative on how to get the money into the infrastructure. They spend a lot of their planning time dealing with issues that are secondary to the actual system—ownership of land, dealing with landowners, etc., versus running a sewer line down the street. A lot of local government is intimidated by dealing with those issues.
Availability of grants for centralized systems but not for onsite systems distorts lifecycle costing (LCC), making centralized appear cheaper	*Grants distort LCC:* The state legislature providing grants is relied on a lot here, apparently in contrast to other states. Unless there is a grant, no one wants to do anything. There's an impact on lifecycle costing, if you take out capital cost. Forty to sixty percent savings from decentralized systems can be erased in the people's minds [if the grant money for a centralized system makes hookup more affordable for individuals than paying all the costs for a less expensive decentralized system].
Funders' conditions, administrative structures, and biases favor use of traditional, centralized approaches.	*Funders don't like uncertainties, like complicated projects that may not come together:* There other layers—funders want a package that will go forward. Many requested projects don't materialize. So they want to not have a lot of contingencies, not a lot of decisions down the line. Like where five jurisdictions have to work together, but don't have an agreement yet. *Centralized is more appealing to funders in terms of lending logistics and administration:* A

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Barriers and Opportunities	Explanations, Examples, and Exceptions
	lot of funding programs are run by engineers who come through centralized programs, and are more comfortable with that. In some cases, there are a lot of logistic and administrative matters that make centralized more appealing to managers. Centralized projects tend to be a whole lot bigger. They would rather write a check for one system as opposed to many checks for decentralized systems for the same amount of people.
	Funders are set up to work with utilities and local government, not individuals, and many onsite management districts don't cut it: Funders are set up to work with utilities and local government. … We have a huge culture of centralized organizations, an extremely less prevalent culture of septic management districts and utility districts. My cynical view is they're mostly on paper. In [state], there is maybe one, and it's a long shot to call it a utility. That's versus 500 government-owned water and wastewater utilities.
	Centralized projects have less administration: If you talk to [person] at ASIWPCA (Association of State and Interstate Water Pollution Control Administrators) about the State Revolving Loan Fund [SRF], she'll say that the reason most money goes to point source projects is that there is less administration.
	Ways to minimize funder interaction with myriad individuals are needed, like linked deposit programs that move the interaction to organizations that are set up for it, like banks: There are financial tricks, ways to minimize the efforts I mentioned. For instance, linked deposit programs. Rather than using the SRF as a bank—because there is no way they want to get involved with 50 homeowners or, at the next level up, dealing with local government but then local government has to deal with becoming a little bank for 50 people—instead, linked deposit programs are structured so the SRF can deal with local banks—which are used to dealing with individuals. So the SRF deals with a few banks rather than 50 individuals.
	Decentralized programs don't go after some funding sources: I have a colleague here who runs an SRF who says he'd be happy to fund a decentralized program, he just needs someone to come borrow for it. Local governments are used to borrowing for schools—clearly a public investment, not something that benefits 50 individuals.
Engineers steer clients in particular directions for funding, usually toward familiar programs oriented toward centralized solutions.	*Engineers are the middlemen between funders and communities, and many are more focused on centralized:* For medium to small communities, engineers play a huge role in being middlemen and facilitating funding. In the public funding arena, the engineer's knowledge is much more than any individual local government. So they play a huge role. They may direct communities to particular funding programs. There are engineers that specialize in SRF projects. There was an article in the paper recently, where a local government went on record about switching engineering firms because one engineer had better relations with a funder. We often get engineers in our training programs, who are working on behalf of local governments.
Other Aspects	
Politics, money, and power within and beyond the engineering profession support centralization	*There are many financial incentives associated with centralization, not just for engineers:* Like in the context of building coalitions to lobby for wastewater funding. Also, labor representatives like centralized systems. Those are big projects with union rates. Any time you can have a situation with one big project, it's easier for states, for engineers, for unions to get involved and control it. It's not just about engineers.
	Campaign finance reform would change the present system: Engineers would not need to contribute to political campaigns to maintain present power structures. Big firms like Parsons, Metcalf and Eddy, CDM have their own contributions to politicians, plus the engineering PACs (political action committees). I just got letter from the PE (professional engineer) society—I need to send in a declaration that I don't want five dollars to go to the PAC, otherwise it goes. And I have to spend 37 cents for a stamp to prevent that.
	It's very difficult to change power structures: No one is going to let go of their power. There's too much money involved.

Table D-2. Barriers Related to Engineers' Lack of Knowledge of Decentralized Systems.

Barrier Category: Engineers' Lack of Knowledge of Decentralized Systems	
Barriers and Opportunities	**Explanations, Examples, and Exceptions**
Universities have limited or no curricula on decentralized.	*Few universities teach decentralized:* Of all civil engineering programs in the U.S., few, other than Texas A&M, the University of Arkansas, the University of Arizona, Colorado School of Mines, the University of Washington, and Michigan State University teach decentralized. By far, more research is done on centralized.
	Education and training courses on decentralized wastewater systems are needed for engineers, scientists, and public health engineers.
	Decentralized is not in the curriculum, so some in the field are self-taught through projects, but with a basis in relevant science and process engineering.
	Most teaching for wastewater systems in the standard curriculum deals with the traditional centralized approach to wastewater collection and treatment: That is the way that the designs are generally performed, and the Ten States' Standards dictates most of the design approach. The ABET (Accreditation Board for Engineering and Technology) requires a curriculum that does not allow a tremendous amount of flexibility in the engineering programs, so students who want to pick up a course in decentralized wastewater systems will have to choose it as one of their technical electives if the course is available. That means giving up an elective in one of the "mainstream" choices.
	A few universities offer courses in decentralized systems: However, most universities do not allow the professor much flexibility or provide much incentive for developing a new course in decentralized systems.
	State regulations on who can be a designer drive curriculum: There aren't programs that say if you do this and that at our institution, you can be a designer. I think the training centers are working toward this. We can only do what the state will accept in the end. If you can't become a designer by taking courses, what's the point of taking the course? But if you haven't taken the course, they can't make you a designer unless you are a professional engineer.
	Even at a university with respected researchers in decentralized, there is only a single two-credit course in the field: Jim Converse's course in decentralized wastewater treatment is a two-credit course. I could easily see it being a full three-credit course. I could see a supplementary course in design of decentralized systems, like to take a case study from NOWRA and work through the options, in particular, for engineers to know the cost and the installation barriers. And things that can come up during installation. So it's not just theory in drafting plans, but also being there while things are being constructed, to learn what to do if site conditions are different than what is expected and how to make decisions with a contractor on making changes.
	The vast majority of students studying wastewater learn only about centralized systems.
	There are no problems on decentralized on the Professional Engineer's (PE) examination: One solution could be to make decentralized systems design part of the PE exam too, for education.
	The academics tend to do research and teach in areas where the money is most available: The decentralized approach is not a very lucrative area of funding.
Professional associations have generally failed to consider decentralized equally with centralized systems.	*Professional associations have not been active in educating members on decentralized, until very recently.*
Documented knowledge of decentralized systems and their performance is not	*The current state of knowledge is a mixed review:* Some of the older municipal engineers and many of the small civil engineering firms have limited knowledge of decentralized systems and are often inclined to think of the negative aspects. Younger engineers and

Barrier Category: Engineers' Lack of Knowledge of Decentralized Systems

Barriers and Opportunities	Explanations, Examples, and Exceptions
widely available.	scientists have more knowledge and are more inclined to delve into the potentially beneficial aspects of decentralized systems. *It's important for engineers to know manufactured technologies are available:* Some engineers have taken the initiative to go out and get training. *Decentralized system information and educational material is now available on-line:* The Consortium of Institutes for Decentralized Wastewater Treatment has developed a curriculum that is posted on their web site, with downloadable reading material and PowerPoint presentations. [www.onsiteconsortium.org] *Examples of successful decentralized systems are important:* Years ago there were no detailed examples. Now we have examples we can show them.
Research funding for decentralized is scarce, and that also reduces the amount and quality of teaching about decentralized	*Funding for research in decentralized is sparse, and research programs give graduate students the solid knowledge that they can go out and apply in the field:* Also, when Jim Converse's replacement is hired, he or she is unlikely to have decentralized as the main research interest, since there is so little money in it, so the level of knowledge will be much lower. *We might think more about onsite systems if there was more money available to do research on them:* Our interests are guided completely by what the National Science Foundation and the research arm of WEF fund, and that's activated sludge. *Decentralized courses are often taught in a "less prestigious" department:* In Massachusetts—the Midwest is different in terms of the dynamics of engineering work—a masters in Biological Systems Engineering [new name for the old Agricultural Engineering department] is not as highly thought of or even as known as in Civil and Environmental Engineering.
The field needs "champions" and educational tools for them	*The field needs to identify who should be the "champions" [to promote the decentralized approach] and develop a way to train and equip them for the job.* *Our group wants to be the local "champion" to help overcome these barriers:* We need the tools: educational help for the public, engineers, and regulators; a pool of knowledge that regulators and engineers can draw from to get a comfort level and to provide the information needed for design and permitting.

Table D-3. Barriers Related to Unfavorability of the Regulatory Environment for Decentralized Systems.

Barrier Category: Unfavorability of the Regulatory Environment for Decentralized Systems

Barriers and Opportunities	**Explanations, Examples, and Exceptions**
Regulators' perceptions and limited knowledge restrict equitable consideration of decentralized systems.	*There is a paternalistic attitude with regulators in general, like "We know what's best, nothing is going to change."* *Regulators have unrealistic, unfair expectations:* People's expectation of perfection is a problem. We have had regulators ask us to prove the fate of every possible virus that could enter the system, or to prove separation to ground water. So we are trying to prove a five foot separation, while some centralized guy is installing raw sewer lines in the ground water. *People who write the regulations haven't studied what they regulate.* *Turnover keeps standards low:* Onsite is the step child; it's where the job openings are but people transfer out fast. So you are constantly dealing with guys with less experience. This keeps the standards low. *There's very little training on the regulatory side:* California uses registered environmental health specialists (REHs) at different levels. Most guys doing inspections and plan checks are that. There are very few engineers. REHs are jacks of all trades.
Regulators need to better define what constitutes system failure and adequate performance	*The issue is, what constitutes a failure?* We have ponding in the failure criteria in the memorandum of agreement. The health department sees failure as moisture on the surface. But sometimes you can have moisture on the surface and it's still OK [e.g., nitrates are still treated]. *For performance-based codes, regulators need to focus on the effluent parameter(s):* They should not use the same requirements as used for surface discharge.
Regulations and codes are often based more on regulating growth than good wastewater choices	*The sanitary code is used as a tool to limit growth:* Systems are required to be on the lot they serve. There is a much more rigorous approval process for shared systems and cluster systems. Most communities would prefer not to have shared systems. They would rather limit growth based on onsite systems for new construction.
A weak regulatory environment can result in inadequate or failure-prone decentralized systems	*Installed systems are only as good as the weakest rules:* "If regulators write rules so the least common denominator system can meet the rules, that's what you get." *Soil treatment capacity is not considered important:* The health department attitude in [state] was that if the effluent remains in the ground and you don't see it, it's OK. A difficulty was overcoming the health department attitude of go out and run a percolation test of the soil; if there's enough hydraulic capacity, just put a leachfield in. *When local regulations differ, the stronger set gets watered down*: The state delegates regulatory authority to local programs. Both the city and the county received their ordinances. That was the basis for enforcement. The city represents the largest part of the county, but the two ordinances did not resemble each other. People who were not satisfied [with stronger regulations of the city], went to the state [for their permit]. So the state pushed to get the ordinances more the same. *Engineers are not involved through and after construction:* There are no regulations [in interviewee's state] to address after construction or that require people to be trained, from the designer to the maintenance company.

Table D-4. Barriers Related to Lack of Systems Thinking.

Barrier Category: Lack of Systems Thinking

Barriers and Opportunities	**Explanations, Examples, and Exceptions**
Wastewater system planning and water resources planning are often not integrated.	*Wastewater plans are not generally part of larger water planning considerations.* *There is a lack of a broader perspective about wastewater problems:* For example, wastewater is seen as a nuisance rather than as a resource. *Distributed reuse, using decentralized wastewater systems, is often not considered in growing areas.* *Comprehensive planning is not comprehensive if it doesn't include consideration of wastewater and natural resources, including hydrology:* The corollary is that comprehensive wastewater planning isn't comprehensive if it doesn't include decentralized. *High water quality standards for reuse where contact with effluent is possible make decentralized systems uneconomical:* Small systems may not have sufficient customers to absorb the high costs of meeting high standards. *The ideal wastewater treatment system would be focused on sustainability:* Our current system is not. The ideal system would maximize the amount of clean water available for all its uses—surface water, groundwater uses, drinking water, fish habitat, whatever—per dollar spent. That's what you want, if you could start at the beginning. We aren't at the beginning.
There is a lack of coordination between local government entities responsible for general planning and those responsible for wastewater infrastructure planning.	*Engineers' and planners' objectives sometimes conflict:* Engineers are comfortable with large lots for onsite systems, while planners often want to achieve increased density. Planners promote "green" technology whereas engineers emphasize technical reliability. *Engineers avoid conflicts:* Conflicts on planning and environmental matters lead engineers to take the path of least resistance, which is often centralized systems. *Elected officials, municipal planning staff, and engineering (or wastewater utility) staff often don't communicate well:* This can lead to the public works department or utility having to play "catch-up" to development promises made by politicians or planners. This usually means the path of least resistance is taken, which is typically sewer extensions. *Engineering precedes planning:* Strong public works departments may get out ahead of the planners with sewer extensions. This kills opportunities to use decentralized systems to manage growth. *Larger annexation areas favor centralized systems to serve them:* Every time we had an annexation proposal, which needed a service plan, we would insist on a look at decentralized, and try to give it a fair shake. It was not exactly unfair, but the size and magnitude of projects [areas to be annexed] seemed to work against us. *Cities use breaks on centralized infrastructure costs as incentives to developers for projects cities want:* When the city began to talk about initiatives for affordable housing, we thought that was an opportunity, because of the maintenance costs of onsite versus centralized. For example, small diameter sewer versus conventional gravity sewer. They [developers] were not quite ready, there was too much opportunity to make money real quick. The city was bending over backwards for affordable housing, so it gave them breaks [on cost] for conventional systems. *Planners need to understand what treatment system works in what types of development:* We need to involve planners in order to assimilate cluster wastewater systems with clustered neighborhoods. Low-impact housing has positive support by governments and the public—we should build on this success. Many planners do not associate the two different systems, central sewers versus decentralized, with the type of development.
Systems thinking is not part of the standard engineering curriculum or the typical	*Systems thinking is not typically taught to engineering students.* *Engineers have the mindset and education that focuses on **the way** to do things, rather than **the function** being provided.*

Barrier Category: Lack of Systems Thinking

Barriers and Opportunities	Explanations, Examples, and Exceptions
engineering culture.	*"Capstone" engineering courses are typically focused on traditional design challenges, rather than holistic analysis of a system and resulting issues in integrative design.* *Watershed courses may not include wastewater:* Engineering students may be exposed to holistic thinking and watershed-level issues in stormwater and hydrology courses, but may not be shown how decentralized wastewater systems can help address watershed problems. *Engineers receive little training in the sorts of broad issues planners deal with.* *Dealing with these broad issues may require a different personality type.* *The engineering paradigm fosters development of narrow, specialized "silos" of expertise.* *Few firms are truly multi-disciplinary.* *Engineers aren't given exposure to the impact of technical solutions on planning goals and vice versa:* I don't know of any policy courses in engineering.

APPENDIX E

Listing of All Identified Barriers and Opportunities

Barrier Category: Engineers' Financial Reward for Using Centralized Systems

General Profitability and Business Strategy Issues

- Decentralized is not seen as a lucrative or strategic area of business.
- Decentralized is seen as lower margin and higher financial risk.
- There is a correlation between community, firm, and system size.
- Success with individual and small systems is difficult.
- Bigger projects yield bigger fees.
- Decentralized is considered a special niche market best exploited by small firms.

Demand Issues

- Few funding programs require thorough consideration of decentralized options
- Attitudes of regulators and municipalities do not support or help create demand for decentralized systems.
- Developers just want what is easy and cheap
- Decentralized systems are seen as atypical or "second rate"
- Clients and the public do not have sufficient knowledge of decentralized options and their characteristics to request engineers to consider them.
- Decentralized solutions are seen as incomplete or too costly, or difficult to construct well
- Clients do not see the added value decentralized can provide (e.g., avoiding the financial commitments of centralized capacity, preserving community character)
- The public does not understand and support management of decentralized systems
- Local governments and publics are leery of government involvement in decentralized systems (e.g., for management)
- Financial institutions that fund wastewater projects prefer to deal with municipalities, not individual homeowners, and municipalities may not be prepared to assume financial responsibility for onsite systems.
- Small communities need technical and managerial assistance
- Strong fiscal pressures exist to increase the number of connections to existing centralized systems, which discourages municipalities from working with decentralized systems.

Funding Availability and Conditions

- Funding is more available for centralized
- Homeowners prefer private ownership, but funding agencies prefer public ownership
- The lack of financial viability of centralized for many communities is not universally recognized
- Funding agencies lack familiarity and experience with decentralized
- Use of public money on private land is legally and administratively problematic.
- Availability of grants for centralized systems but not for onsite systems distorts lifecycle costing (LCC), making centralized appear cheaper
- Funders' conditions, administrative structures, and biases favor use of traditional, centralized approaches
- Engineers steer clients in particular directions for funding, usually toward familiar programs oriented toward centralized solutions.

Engineering Costs

- Developing and maintaining decentralized engineering expertise is costly
- A "production" focus (versus innovative problem solving) means many firms stick with a few technologies they know
- Firms stick to technologies they know will pass regulatory hurdles without extra work
- Decentralized requires more public involvement/interaction, which can be costly
- It's easier and more profitable for engineers to help clients finance centralized systems
- Decentralized systems are seen as diverting resources from centralized system management

Liability Concerns

- Engineers' perceptions of liability are influenced by notable failures and by myths about decentralized

Barrier Category: Engineers' Financial Reward for Using Centralized Systems
Engineers see greater liability with smaller than larger systems, in part due to a lower level of user control for smaller systems
Engineers reduce liability exposure by sticking with a few familiar technologies
It is difficult for contractors to get bonded to do decentralized systems
Developers, builders, and lot buyers need protection from the regulatory risk posed by future construction of decentralized systems
Engineering Culture
Engineers get little recognition for decentralized systems
Young engineers face fewer career opportunities and lower pay in decentralized.
Engineers are not well-equipped or disposed to advise property owners
Engineers seldom take a leadership role in educating clients
Different business models and staffing strategies may be required for success with decentralized systems
Other Aspects
Politics, money, and power within and beyond the engineering profession support centralization

Barrier Category: Engineers' Lack of Knowledge of Decentralized Systems
Universities have limited or no curricula on decentralized technology and management..
Few engineering students study decentralized wastewater engineering
On-the-job training is the way most practicing engineers and scientists are educated in decentralized.
Decentralized technology is evolving, and engineers don't keep up with it.
Professional associations have generally failed to consider decentralized equally with centralized systems.
Documented knowledge of decentralized systems and their performance is not widely available.
Many local government engineers don't know decentralized systems well
Regulatory engineers' knowledge of decentralized is limited.
Research funding for decentralized is scarce, and that also reduces the amount and quality of teaching about decentralized
Funding agency engineers are not very aware of decentralized technologies
The field needs "champions" and educational tools for them
Training opportunities for interested engineers are growing.

Barrier Category: Engineers' Unfavorable Perception of Decentralized Systems
Lack of examples of decentralized system management restricts acceptance of decentralized.
Decentralized systems are perceived as requiring too much or too onerous management.
Engineers are conservative, and decentralized options seem too risky.
Engineers operating within the traditional paradigm have difficulty seeing the benefits of decentralized and solutions to issues with decentralized.
Negative terms limit the consideration of decentralized technology and management.
Decentralized is viewed as a temporary solution, yet it can be difficult to change to centralized.
The perception is that there are limited onsite technologies available.
Political pressure can force consideration of certain options.
Notable failures negatively affect the perception of decentralized systems.

Barrier Category: Lack of Systems Thinking
The multi-source nature of water quality problems in most watersheds is not well-recognized; too often onsite systems take most of the blame.
There is a lack of understanding of and attention to the hydrologic implications of wastewater infrastructure choices.
Wastewater system planning and water resources planning are often not integrated.
Differences between wastewater options in terms of effects on community growth and character are not well understood or considered.
There is a lack of coordination between local government entities responsible for general planning and those responsible for wastewater infrastructure planning.
The advantages of decentralized systems with respect to infrastructure security issues are not widely recognized.
Tendencies to focus on short-term costs rather than lifecycle costs hamper consideration of decentralized systems.
Consumers of engineering services (municipalities, etc.) are often focused on single-purpose projects.
Lack of robust alternatives analysis leads to less holistic solutions.

Barrier Category: Lack of Systems Thinking
Systems thinking is not part of the standard engineering curriculum or the typical engineering culture.
Success with centralized systems requires less human interaction, making them easier to develop.

Barrier Category: Unfavorability of the Regulatory Environment for Decentralized Systems
Inconsistent regulations limit engineers' ability to consider decentralized equitably.
Many regulators discourage or are at best neutral on decentralized, while some regulators encourage or require its consideration.
Risk-averse regulators thwart equitable consideration of decentralized.
Strict, ill-founded, incomplete, and changing regulations frustrate consideration and use of decentralized systems.
Adequacy of decentralized system management is questioned by some regulators.
Regulators' perceptions and limited knowledge restrict equitable consideration of decentralized systems.
Regulators don't often challenge an engineer's dismissal of decentralized options.
Regulations often are not tailored to or accommodating of decentralized systems
Health regulators are focused on enforcement, driven by complaints, rather than good wastewater planning
The TMDL process may be biased against decentralized systems
Permitting costs are less for large centralized systems
Treatment claims for decentralized systems are not well made, resulting in lack of environmentalist support for regulations that are friendly to decentralized systems.
Regulators need to better define what constitutes system failure and adequate performance
Regulations and codes are often based more on regulating growth than good wastewater choices
A weak regulatory environment can result in inadequate or failure-prone decentralized systems
Licensing and certification rules are often inadequate

APPENDIX F

TABLES: OVERVIEW OF STRATEGIES AND ACTIONS BY BARRIER

Table F-1. Strategies and Actions Directed at Overcoming Barriers in the Category "Engineers' Financial Reward for Using Centralized Systems"

Barrier	Strategy	Action
Barrier 1A: Few funding programs require thorough consideration of decentralized options, and engineers tend not to give decentralized thorough consideration without the requirement from the funding program	2.1 Increase availability of financial assistance for decentralized systems	2.1.1 Implement funding set-asides and project review and ranking criteria that remove biases and encourage greater use of decentralized systems 2.1.2 Implement new loan fund models 2.1.3 Establish tax credits for onsite system upgrades
	2.2 Require consideration of decentralized options in regulatory and funding processes	2.2.1 Require serious consideration of decentralized options in facility plans
Barrier 1B: Attitudes of regulators and municipalities do not support or help create demand for decentralized systems.	2.3 Increase public awareness and address misperceptions around decentralized systems 4.1 Achieve greater uniformity in decentralized system regulations 4.2 Broaden support for science-based regulation of decentralized treatment	2.3.1 Educate local government officials on the financial advantages of decentralized systems 4.1.1 Identify model regulations 4.1.2 Complete and use the Decentralized Wastewater Glossary 4.2.1 Engage environmental groups and planners to support the decentralized approach
Barrier 1C: Developers just want what is easy and fast to permit, and cheap	None	None
Barrier 1D: Decentralized systems are seen by home buyers as atypical or "second rate"	None	None
Barrier 1E: Clients and the public do not have sufficient knowledge of decentralized options and their characteristics to request engineers to consider them.	2.2 Require consideration of decentralized options in regulatory and funding processes (see also Barrier 1A above)	2.2.1 Require serious consideration of decentralized options in facility plans See Barrier 1A above
Barrier 1F: Decentralized solutions are seen as incomplete or too costly, or difficult to construct well	None	None
Barrier 1G: Clients do not see the added value decentralized can provide (e.g., avoiding the financial commitments of centralized capacity, preserving community character)	2.3 Increase public awareness and address misperceptions around decentralized systems 4.2 Broaden support for science-based regulation of decentralized treatment	2.3.1 Educate local government officials on the financial advantages of decentralized systems See Barrier 1B above 4.2.1 Engage environmental groups and planners to support the decentralized approach
Barrier 1H: The public does not	None	None

Barrier	Strategy	Action
understand and support management of decentralized systems		
Barrier 1I: Local governments and publics are leery of government involvement in decentralized systems (e.g., for management)	None	None
Barrier 1J: Financial institutions that fund wastewater projects prefer to deal with municipalities, not individual homeowners, and municipalities may not be prepared to assume financial responsibility for onsite systems.	2.1 Increase availability of financial assistance for decentralized systems	2.1.1 Implement funding set-asides and project review and ranking criteria that remove biases and encourage greater use of decentralized systems 2.1.2 Implement new loan fund models 2.1.3 Establish tax credits for onsite system upgrades
Barrier 1K: Small communities need technical and managerial assistance	None	None
Barrier 1L: Strong fiscal pressures exist to increase the number of connections to existing centralized systems, which discourages municipalities from working with decentralized systems.	2.3 Increase public awareness and address misperceptions around decentralized systems (see also Barrier 1B above)	2.3.1 Educate local government officials on the financial advantages of decentralized systems See Barrier 1B above
Barrier 1M: Funding is more available for centralized	2.2 Require consideration of decentralized options in regulatory and funding processes (see also Barrier 1A above) 2.4 Adopt new business models for engineering firm success with decentralized systems	2.2.1 Require serious consideration of decentralized options in facility plans See Barrier 1A above 2.4.1 Implement alternative marketing strategies 2.4.2 Implement alternative ways to compensate engineers for recommending decentralized systems
Barrier 1N: Homeowners prefer private ownership, but funding agencies prefer public ownership	2.1 Increase availability of financial assistance for decentralized systems	2.1.1 Implement funding set-asides and project review and ranking criteria that remove biases and encourage greater use of decentralized systems 2.1.2 Implement new loan fund models 2.1.3 Establish tax credits for onsite system upgrades
Barrier 1O: The lack of financial viability of centralized for many communities is not universally recognized	2.3 Increase public awareness and address misperceptions around decentralized systems	2.3.1 Educate local government officials on the financial advantages of decentralized systems
Barrier 1P: Funding agencies lack familiarity and experience with decentralized systems or management.	None	None
Barrier 1Q: Use of public money on private land is legally and administratively problematic.	2.1 Increase availability of financial assistance for decentralized systems	2.1.1 Implement funding set-asides and project review and ranking criteria that remove biases and encourage greater use of decentralized systems 2.1.2 Implement new loan fund models 2.1.3 Action: Establish tax credits for onsite system upgrades
Barrier 1R: Funders' conditions, administrative structures, and biases affect consideration of decentralized	2.1 Increase availability of financial assistance for decentralized systems	2.1.1 Implement funding set-asides and project review and ranking criteria that remove biases and encourage greater use of decentralized systems 2.1.2 Implement new loan fund models

Barrier	Strategy	Action
		2.1.3 Establish tax credits for onsite system upgrades
Barrier 1S: Engineers steer clients in particular directions for funding, usually toward familiar programs oriented toward centralized solutions.	2.1 Increase availability of financial assistance for decentralized systems	2.1.1 Implement funding set-asides and project review and ranking criteria that remove biases and encourage greater use of decentralized systems 2.1.2 Implement new loan fund models 2.1.3 Establish tax credits for onsite system upgrades
Barrier 1T: Politics, money, and power within and beyond the engineering profession support centralization	2.1 Increase availability of financial assistance for decentralized systems	2.1.1 Implement funding set-asides and project review and ranking criteria that remove biases and encourage greater use of decentralized systems 2.1.2 Implement new loan fund models 2.1.3 Establish tax credits for onsite system upgrades

Table F-2. Strategies and Actions Directed at Overcoming Barriers in the Category "Engineers Lack Knowledge of Decentralized Wastewater Treatment Systems".

Barrier	Strategy	Action(s)
Barrier 2A: Universities have limited or no curricula on decentralized technology and management.	3.1 Increase teaching of decentralized systems	3.1.1 Universities teach engineering students a minimum of two classroom hours in soil-based treatment and decentralized technologies 3.1.2 Universities or other organizations teach continuing education courses in decentralized 3.1.3 Increase funding for university decentralized research 3.1.4 Develop decentralized questions for the Professional Engineers exam
Barrier 2B: Professional associations have generally failed to consider decentralized equally with centralized systems	None	None
Barrier 2C: Documented knowledge of decentralized systems and their performance is not widely available	3.2 Increase data on decentralized technologies	3.2.1 An RME applies reliability and costing tools to decentralized systems in an asset management framework
Barrier 2D: Research funding for decentralized is scarce, and that also reduces the amount and quality of teaching about decentralized	3.1 Increase teaching of decentralized systems	3.1.1 Universities teach engineering students a minimum of two classroom hours in soil-based treatment and decentralized technologies 3.1.2 Universities or other organizations teach continuing education courses in decentralized 3.1.3 Increase funding for university decentralized research 3.1.4 Develop decentralized questions for the Professional Engineers exam
Barrier 2E: The field needs "champions" and educational tools for them	None	None

Table F-3. Strategies and Actions Directed at Overcoming Barriers in the Category "Unfavorability of the Regulatory Climate for Decentralized Systems"

Barrier	Strategy	Action
Barrier 3A: Regulators' perceptions and limited knowledge restrict equitable consideration of decentralized systems	4.1 Achieve greater uniformity in decentralized system regulations	4.1.1 Identify model regulations 4.1.2 Complete and Use the Decentralized Wastewater Glossary
Barrier 3B: Regulators need to better define what constitutes system failure and adequate performance	Alter priority point rankings for funding municipal projects (see also Barriers 1A and 1J in Table 1)	See Barriers 1A and 1J
	2.1 Increase availability of financial assistance for decentralized systems	2.1.1 Implement funding set-asides and project review and ranking criteria that remove biases and encourage greater use of decentralized systems 2.1.2 Implement new loan fund models 2.1.3 Establish tax credits for onsite system upgrades
Barrier 3C: Regulations and codes are often based more on regulating growth than good wastewater choices	None	Disseminate existing case study literature
Barrier 3D: A weak regulatory environment can result in inadequate or failure-prone decentralized systems	4.1 Achieve greater uniformity in decentralized system regulations. (See Barrier 3A, above)	4.1.1 Identify model regulations 4.1.2 Complete and use the Decentralized Wastewater Glossary
	4.3 Manage system information: Permits, maintenance, inspections, and monitoring	4.3.1 Regulators promote high-quality permit, maintenance, and monitoring programs 4.3.2 Regulators evaluate simplified tracking databases and publicize them if they are helpful 4.3.3 Manufacturers' engineers track operations and maintenance of their systems

Table F-4. Strategies and Actions Directed at Overcoming Barriers in the Category "Lack of Systems Thinking".

Barrier	Strategy	Action
Barrier 4Ai: Wastewater system planning and water resources planning are often not integrated: Wastewater plans are not generally part of larger water planning considerations. Comprehensive water planning includes wastewater (centralized and decentralized), stormwater, water supply, and hydrology	5.1 Require wastewater planning to include relationships to other water sectors	5.1.1 Develop guidelines for linking wastewater to other sectors
	5.2 Utilities encourage integrated water resources approaches	5.2.1 Utilities employ integrated resource planning 5.2.2 Utilities investigate offering developers incentives for water reuse 5.2.3 Utilities encourage LEED certification for new construction and renovation
Barrier 4Aii: Wastewater system planning and water resources planning are often not integrated: There is a lack of a broader perspective about wastewater problems. For example, wastewater is seen as a nuisance rather than as a resource	2.3 Increase public awareness and address misperceptions around decentralized systems	2.3.1 Educate local government officials on the financial advantages of decentralized systems
	3.1 Increase teaching of decentralized systems	3.1.1 Universities teach engineering students a minimum of two classroom hours in soil-based treatment and decentralized technologies 3.1.2 Universities or other organizations teach continuing education courses in decentralized 3.1.3 Increase funding for university decentralized research 3.1.4 Develop decentralized questions for the Professional Engineers exam
	3.2 Increase data on decentralized technologies	3.2.1 An RME applies reliability and costing tools to decentralized systems in an asset management framework
Barrier 4Aiii: Wastewater system planning and water resources planning are often not integrated: Distributed reuse, using decentralized wastewater systems, is often not considered in growing areas.	None	None
Barrier 4Aiv: Wastewater system planning and water resources planning are often not integrated: High water quality standards for reuse where contact with effluent is possible make decentralized systems uneconomical; small systems may not have sufficient customers to absorb the high costs of meeting high standards	None	None
Barrier 4Av: Wastewater system planning and water resources planning are often not integrated: Put wastewater treatment plants in a sustainability context	5.3 Train engineers in broad systems thinking	5.3.1 Train undergraduate engineers in broad systems thinking 5.3.2 Train practicing engineers in broad systems thinking
Barrier 4B: There is a lack of coordination between local government entities responsible for general planning and those responsible for wastewater infrastructure planning	None	None
Barrier 4C: Broad systems thinking is not part of the standard engineering curriculum or the typical engineering culture	5.1 Require wastewater planning to include relationships to other water sectors	5.1.1 Develop guidelines for linking wastewater to other sectors

Barrier	Strategy	Action
	5.2 Utilities encourage integrated water resources approaches	5.2.1 Utilities employ integrated resource planning 5.2.2 Utilities investigate offering developers incentives for water reuse 5.2.3 Utilities encourage LEED certification for new construction and renovation
	5.3 Train engineers in broad systems thinking	5.3.1 Train undergraduate engineers in broad systems thinking 5.3.2 Train practicing engineers in broad systems thinking

APPENDIX G

ENGINEERING SOCIETIES

Engineers have the opportunity to influence change not only as individuals or through their employers, but also through professional organizations they belong to. As the project team brainstormed ways to overcome barriers, profiles were created of engineering societies and other professional organizations that engineers join. Some profiles were simply distilled from the organization’s web page; others were also the products of interviews with one or more individuals at the organization. The project team found the profiles helpful in designing ways to overcome barriers; they are included here in the hope that they may be of use to others who wish to implement actions listed herein.

G.1 Engineering Society Profile: American Academy of Environmental Engineers (AAEE)

Contact Information

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www.aaee.net

History and Purpose

The American Academy of Environmental Engineers® (AAEE) was founded in 1955 for the principal purpose of serving the public by improving the practice, elevating the standards, and advancing public recognition of environmental engineering through a program of specialty certification of qualified engineers. Their mission as stated on their website is “dedicated to excellence in the practice of environmental engineering to ensure the public health, safety, and welfare to enable humankind to co-exist in harmony with nature.” Five staff members are listed on the web.

The American Academy of Environmental Engineers provides a structure for advancing environmental engineering careers through the Members Program and the Board Certified Environmental Engineer (BCEE, also referred to as Diplomate) certification that gives full membership in the Academy. The BCEE or DEE title is an internationally recognized credential that is accepted as the hallmark of premier environmental engineers. One of the specialties is “Water Supply/Wastewater Engineering.”

Some of the benefits of becoming a BCEE include:

- Objective testimony to special expertise and level of proficiency beyond that which is required to practice as a professional engineer.
- A biographical listing as a BCEE in Who's Who in Environmental Engineering—the recognized guide to the current leaders in environmental engineering

Membership

There are two classes of members. Recent graduates with an EIT certificate or recently licensed (registered) engineers working in environmental engineering but without the eight years of experience required for specialty certification can take advantage of the benefits that the Academy has to offer through the Member program. Licensed, professional environmental engineers with at least eight years of full-time environmental engineering experience are eligible for specialty certification that provides independent testimony to individual expertise and qualifies engineers for full membership in the Academy as a Board Certified Environmental Engineer (BCEE). To maintain this certification, each BCEE is required to obtain a specified minimum amount of continuing professional development each year to remain current with changing environmental engineering practice.

Activities with Potential to Address Barriers:

The Kappe Lecture Series was inaugurated by the Academy in 1989 to share the knowledge of today's practitioners with tomorrow's environmental engineers. It is an annually recurring series of lectures presented on college campuses during the fall academic term. Following are descriptions of two current lectures.

Lecture A: Engineering for Water Quality, Institutional Limits on Optimization

In the U.S. and in much of the rest of the developed world, increasing expenditures for pollution control have been made through existing companies and institutions. The great leap forward that occurred after World War II provided the basis for a new era in the 1970s with the Clean Water Act, the Safe Drinking Water Act, and the creation of U.S.EPA. Many states matched the federal government with new organizations and laws. Except for administrative reorganizations and some inter-basin planning groups, the agencies building and operating new facilities and planning for environmental management are not matched to the problem. The development of plans, regulations, and projects to control and improve water quality for both drinking water and environmental benefits takes place in the context of the existing institutions and the laws that govern them. By and large, they were established to achieve different objectives and within geographical and political jurisdictions that do not reflect today's engineering, scientific and technical needs for water management.

Engineers have designed individual projects and plan regionally to achieve water quality objectives; notwithstanding the impediments that prevent them from considering and achieving the best results. Regulators and project funders have continually emphasized the need for consolidation and regionalization of water and wastewater systems, while local institutions have fought to preserve their territorial and jurisdictional entitlements. These conflicts make it difficult for engineers to achieve the best results. Engineering planning requires a new level of creativity that would include a rebirth of "engineering economy", an emphasis on effectively using data sources, and creative ways of developing projects to involve these mismatched institutions in achieving solutions.

This lecture will discuss three cases and provide alternative ways for engineers to address impediments to effective planning and project development. The cases include the City of Pittsburgh's attempt to control combined sewer overflows and the resulting Water Science and Technology Board 2005 Study; the conflicts between in-stream objectives and drinking water quality in the Sacramento River and San Joaquin Delta area of California; and the relationship between land-use controls and the construction of filtration plants for the City of New York, Seattle, and San Diego County Water Authority.

Lecture B: Improving Drinking Water Quality, Enforcing Standards versus Requiring a Technology

Drinking water quality standards have been developed to protect public health. They are adopted, sometimes with considerable controversy, by the federal government and the individual states. They serve as the basis for the design of drinking water treatment works, and as well as the future planning of water supply development. They are based on a fundamental concept that "maximum contaminant levels" (MCLs) should be set for each contaminant, with planners and engineers designing systems to achieve these levels. In addition, the requirements include MCL goals that are frequently established at zero. The time has come to reconsider this concept since, in the last 50 years, there has been a significant improvement in the knowledge base used to establish standards and in the technology available to meet them.

The threat of litigation and negative public reaction to the presence of detectable contaminants create impractical, imprecise, and expensive design targets. But water rate payers would benefit by using new sources of information and tools for improvement in an integrated and balanced way to achieve the best result for the system investment while still providing for safe water. This presentation will discuss the impact of current standard setting and concepts of regional planning. It will describe conflicting objectives and attempts to achieve an optimal result in drinking water quality and treatment projects and source development. Case studies will focus on contaminant control requirements of California's Proposition 65, attempts to respond to the presence of MTBE in groundwaters at South Tahoe, Santa Monica; control of a perchlorate in Sacramento in Southern California, and standards for the control of cryptosporidium and giardia organisms that have affected the relationship between technology and land-use controls at Seattle, San Diego, and in the New York City watershed.

G.2 Engineering Society Profile: Accreditation Board for Engineering and Technology (ABET)

Contact Information

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www.abet.org

History and Purpose

ABET was established in 1932, and is the recognized accreditor for college and university programs in applied science, computing, engineering, and technology.

ABET currently accredits some 2,700 programs at over 550 colleges and universities nationwide, with a staff of approximately 35 people. Over 1,500 dedicated volunteers participate annually in ABET activities. Accreditation ensures the quality of the postsecondary education students receive. Individual members of these societies - practicing professionals from industry and academe - form the body of ABET through its program evaluators (PEVs), Board of Directors, and four accreditation commissions, the Applied Science Accreditation Commission (ASAC), Computing Accreditation Commission (CAC), Engineering Accreditation Commission (EAC), and Technology Accreditation Commission (TAC). There are several active councils and committees within ABET. ABET also provides leadership internationally through agreements such as the Washington Accord and offers educational credentials evaluation services to those educated abroad through ECEI.

Membership

ABET is a federation of 28 professional and technical societies.

Activities with Potential to Address Barriers:

- ABET does not accredit programs outside the United States. However, ABET does evaluate programs outside the U.S., by institutional request, in order to determine if they are "substantially equivalent" to ABET-accredited programs and to make recommendations for program improvement.
- The 3rd ABET International Congress on Education, Accreditation, and Practice will be held on October 26 and 27, 2006 (www.abet.org/register.shtml). ABET invites deans, faculty, administrators, industry leaders, government representatives, grant-makers, researchers, accrediting bodies, professional societies, and invested foundations and organizations all to participate.
- In 1997, ABET adopted Engineering Criteria 2000 (EC2000), considered at the time a revolutionary approach to accreditation criteria. EC2000 focused on what is learned rather than what is taught. At its core was the call for a continuous improvement process informed by the specific mission and goals of individual institutions and programs. EC2000 meant that ABET could enable program innovation and encourage new assessment processes and subsequent program improvement.

G.3 Engineering Society Profile: American Council of Engineering Companies (ACEC)

Contact Information

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History and Purpose

The American Council of Engineering Companies, formerly known as the American Consulting Engineers Council, was founded in 1910. Its core purpose according to its 2005 Strategic Action Plan is “To promote the business interests of engineering companies by providing legislative advocacy and business services.” According to its website, the ACEC/PAC is the largest political action committee in the applied engineering (A/E) industry.

The Council is governed by a national board of directors who represent 51 state and regional councils called Member Organizations (MOs). The president and a staff of 45 administer the core programs. The Council focuses on government advocacy and educational programs focused on business and legal matters. There are 23 different committees whose primary functions are to advance the Council's Strategic Plan. The council is known for its engineering excellence awards. The journal Engineering Inc. is a bimonthly magazine published by ACEC, and The Last Word is a newsletter that includes legislative and business information.

Membership:

The ACEC includes nearly more than 17,000 members in 5,500 member firms covering the range of engineering practices (civil, structural, electrical, etc.).

Activities with Potential to Address Barriers:

- One of the core values described in the 2005 Strategic Action Plan included, "promoting sustainability in the natural and built environments."
- ACEC/PAC is a strong advocate for engineering related issues. Their action plan includes a target of growing the ACEC/PAC to a $1million/year PAC by 2010.
- The Institute for Business Management includes five subcommittees including certification, licensure, and curriculum.
- ACEC has developed coalitions with other organizations when "engineering firms wish to pursue specific business issues requiring more intense activity than that currently being offered by the Council". Five coalitions are listed on their website: Council of American Mechanical & Electrical Engineers (CAMEE), Council of American Structural Engineers (CASE), Council of Professional Surveyors (COPS), Design Profession Coalition (DPC), and Small Firm Council (SFC).
- A Senior Executives Institute is offered to "provide unparalleled opportunities for A/E executives to understand and eventually lead in the complex national and international business and policy arenas."
- ACEC national awards are geared to very large projects, but member organization awards include a range of size and type of projects that allow smaller projects to be recognized. For example, the Warren, Vermont EPA demonstration project received two Grand Awards through its state organization (ACEC/VT): one for a pilot innovative wastewater treatment system at the elementary school, and one for the entire decentralized wastewater project.
- A state organization (Florida Engineering Society) website indicated they give awards to legislators and other government officers who "recognize the importance of the role of the profession in the protection of health and welfare of the citizens of Florida."

G.4 American Public Works Association (APWA)

Contact Information

Kansas City Missouri Office (there is also a Washington, D.C. office)
2345 Grand Boulevard, Suite 700
Kansas City, MO 64108-2625
Phone: (816) 472-6100, Fax: (816) 472-1610
http://www.apwa.net/

History and Purpose:

The American Public Works Association is an international educational and professional association of public agencies, private sector companies, and individuals dedicated to providing high quality public works goods and services. Originally chartered in 1937, APWA is the largest and oldest organization of its kind in the world, with headquarters in Kansas City, Missouri, an office in Washington, D.C., and 67 chapters throughout North America. APWA provides a forum in which public works professionals can exchange ideas, improve professional competency, increase the performance of their agencies and companies, and bring important public works-related topics to public attention in local, state and federal arenas.

Membership:

APWA is a highly participatory organization, with hundreds of opportunities for leadership and service, and a network of several dozen national committees in every area of public works. Governed by a 17-member board of directors, elected at both the regional and national levels, APWA is an open, flexible association with a diversified membership of 26,000 and a reputation for quality services and products.

Activities with Potential to Address Barriers:

- Advocacy activities such as submitting briefings for or testifying at Legislative hearings (http://www.apwa.net/advocacy/RuralAdvocacy.asp)
- Conferences/tradeshows, most notably the International Public Works Congress and Exposition
- A variety of educational resources, including:
- Click, Listen & Learn Programs (2-hour internet training sessions)
- Web-based training programs
- Live workshops
- Educational videos and CD-ROMs
- Publications such as the APWA Reporter, a monthly magazine/newsletter
- Website's Resource Center contains sections on "Rural and Small Communities" (a few general links including one to NSFC), "Livable Communities" (mostly smart growth links), and "Water Resources" (currently geared to centralized water/wastewater operations)

G.5 Engineering Society Profile: American Society of Agricultural and Biological Engineers (ASABE)

Contact Information

2950 Niles Road, St. Joseph, MI 49085
Tel. (269) 429-0300, Fax (269) 429-3852
www.asabe.org

History and Purpose

The American Society of Agricultural and Biological Engineers (ASABE), formerly known as the American Society of Agricultural Engineers (ASAE), was founded in 1907. According to its website, it is "an educational and scientific organization dedicated to the advancement of engineering applicable to agricultural, food, and biological systems". The society defines the practice of biological engineering as the application of the engineering method to the design of machines, processes, components, materials, and associated systems whose effectiveness cannot be optimized without accounting for the anatomy, physiology, or function of living materials, organisms, or communities.

ASABE became a participating member of ABET (at the time, the Engineers' Council for Professional Development (ECPD)) in December 1966. ASABE is the lead society for accreditation of agricultural and similarly named engineering programs and a cooperating society for accreditation of bioengineering programs and environmental engineering programs. As biologically based engineering curricula continue to evolve, ASABE is best positioned among engineering societies to provide leadership and facilitation for biological engineering program criteria."

ASABE has an annual budget of $3 million and a staff of about 30. Activity areas include engineering standards, public affairs, publications, forums, continuing education, employment, and scholarships, grants and foundation. ASABE publications include a journal, standards, white papers, books, and conference proceedings of technical papers.

Membership:

ASABE has over 9,000 members representing over 100 countries. Members include licensed professional engineers, engineers in training, graduates of ABET-accredited engineering schools, or engineering students.

Activities with Potential to Address Barriers:

- Conferences - 11th National Symposium on Individual and Small Community Sewage Systems
- Committee Work –Many of ASABE's committees could help address barriers. Following is a list of some of the committee names
    - ED-203 Undergraduate & Graduate Instruction
    - ED-204 Engineering Technical and Management Accreditation
    - ED-205 Engineering Licensure – service related to national Principles & Practices Exam (PE Exam)
    - ED-210 Academic Program Administration – members include all head, college level administrators of academic programs in U.S. and Canada
    - ED-416 Continuing Professional Development – establishes policy and procedures for continuing education
    - ESH-02 Policy & Forward Planning
    - IET-254 Emerging Information Systems
    - SW-26 Countryside Engineering Group - Concerns the orderly development of land resources, and the balancing of multifold stresses on the land with the essential capacity of the land resource to produce food and fiber.
    - SW-262 Home Sewage Disposal - Addresses issues in home sewage disposal.
    - SW-263 Land Application of Waste - Addresses issues in the land application of waste.
- Student Advisory Board
- White papers/engineering statements
- Various awards and scholarships

- Student Organizations—divided by state (includes university contacts for advisors)

G.6 Engineering Society Profile: American Society of Civil Engineers (ASCE)

Contact Information

ASCE Washington Office
101 Constitution Avenue, NW, Ste. 375 East
Washington, D.C. 20001
800-548-ASCE (2723) ext. 7850
202-789-7850 Government Relations Department
202-789-7859 Government Relations fax
www.asce.org
ASCE World Headquarters is in Reston, Virginia 20191-4400

History and Purpose

According to their website, "Founded in 1852, the American Society of Civil Engineers (ASCE) is America's oldest national engineering society. ASCE's vision is to position engineers as global leaders building a better quality of life. ASCE's mission is to provide essential value to our members, their careers, our partners and the public by developing leadership, advancing technology, advocating lifelong learning and promoting the profession."

"More than 6,200 civil engineers serve on more than 600 national committees that produce the Society's annual convention, specialty conferences, publications, policies, building codes and standards, and other services that benefit the Society." The total budget for ASCE and its affiliates is $50.0 million for FY 2005. ASCE is a 501(c)(3) tax-exempt organization. Products and services include the Civil Engineering Magazine, conferences, continuing education, contract documents, online research library, e-newsletter, honors and awards, NAACE foundation, and several publications.

Membership:

ASCE represents more than 137,500 members of the civil engineering profession worldwide. The Society includes over 400 local affiliates, four Younger Member Councils, 230 Student Chapters, 36 Student Clubs and six International Student Groups.

Activities with Potential to Address Barriers:

- ASCE plans, organizes, and conducts activities supporting the formal education process of civil engineers. Recent initiatives include the nationally-acclaimed ExCEEd (Excellence in Civil Engineering Education) Teaching Workshops that develop college faculty into effective teachers, and the Practitioner and Faculty Advisor Training Workshop that improves the leadership skills of student chapter/club advisors. To provide middle and high school students with an opportunity to learn about civil engineering through a realistic, hands-on design experience, ASCE is the primary sponsor of the fourth annual West Point Bridge Design Contest.
- ASCE is the world's largest publisher of civil engineering information. The Society publishes the monthly magazine Civil Engineering, a monthly newspaper ASCE News, the quarterly Geo-Strata for the Geo-Institute, 30 technical and professional journals, and a

variety of books including conference proceedings (available online), committee reports, manuals of practice, standards, and monographs under the ASCE Press imprint. The 125,000-entry civil engineering database is available at www.pubs.asce.org, along with many other resources for practicing civil engineers including a complete catalog of ASCE publications.

- Informing civil engineers about new innovations in civil engineering, the Society holds 15-20 technical conferences annually, with an average total attendance of 10,000. Each year, the Society also offers more than 275 continuing education seminars, workshops, distance learning programs, and customized in-company training programs. ASCE offers Continuing Education Units (CEUs) and/or Professional Development Hours (PDHs) for conferences, seminars and workshops, and most distance learning programs to help professional engineers meet mandatory continuing professional competency requirements in their states.
- ASCE encourages its local affiliates to support state and local public and governmental affairs activities. The Key Contact Program, with 9,310 members, gives the Society a strong voice in Washington and in state capitals on engineering issues. The Society's federal priority issues for the 109th Congress are clean water, math and science education, natural hazards mitigation and infrastructure security, and smart growth/sustainable development. The state priority issues that may be relevant to addressing barriers include building codes, infrastructure financing, licensing, and smart growth.
- Engineering the Future of Civil Engineering (October 2001). This document is a report from the ASCE Task Committee on the First Professional Degree. This Task Committee worked to "develop a vision of full realization of ASCE Policy 465 (regarding the first professional degree) and a strategy for achieving this vision." The report concludes that the requisite body of specialized knowledge required to practice as a professional civil engineer is best obtained through a combination of an engineering baccalaureate degree and a master's degree or equivalent. (The report contains some interesting ideas regarding engineers' current barriers to future problem solving.)

The American Society of Civil Engineers contributes to the development of civil engineering students and professionals through a variety of educational programs.

- Committee on Curricula and Accreditation (CC&A)
- Committee on Faculty Development (CFD)
- Committee on the National Concrete Canoe Competition
- Committee on Scholarships (COS)
- Committee on Student Activities (CSA)
- Committee on Technology Curricula and Accreditation (CTC&A)
- Department Heads Council Executive Committee (DHC)
- Department Heads Council Regions
- Educational Activities Executive Committee
- Education and Practice Publications Committee (EPPC)
- Education Programs Committee (EPC)

G.7 Engineering Society Profile: American Water Works Association (AWWA)

Contact Information

AWWA, 6666 W. Quincy Avenue
Denver, CO 80235
Telephone: 303.794.7711 or 800.926.7337
Fax: 303.347.0804
www.awwa.org

History and Purpose

Per their website, the American Water Works Association (AWWA) is an international nonprofit scientific and educational society dedicated to the improvement of water quality and supply. Founded in 1881, AWWA is the largest organization of water supply professionals in the world. AWWA is well-known for developing construction and management standards for water system construction and operation and maintenance. They also host conferences and develop various publications.

Membership:

Its more than 57,000 members represent the full spectrum of the water community: treatment plant operators and managers, scientists, environmentalists, manufacturers, academicians, regulators, and others who hold genuine interest in water supply and public health. Membership includes more than 4,700 utilities that supply water to roughly 180 million people in North America.

Activities with Potential to Address Barriers:

- Small systems resource center – the website includes links to wastewater information including the University of Minnesota's guidance document and the State of Virginia documents
- Advocacy – with an emphasis water source protection
- Education – conferences, seminars, online training opportunities
- Journals – WaterWeek, e-Journal
- Relate to water standards
- They are promoting a white paper entitled, "Utilities helping Utilities" related to security issues. This could be enhance to become a way to enable small water utilities to help with wastewater utility development for rural communities

G.8 Groundwater Research Association of California (GRA)

Contact Information

915 L Street, Suite 1000
Sacramento, CA 95814
Phone: (916) 446-3626, Fax: (916) 442-0382
http://www.grac.org/

History and Purpose:

GRA was formed in 1992 to promote the protection of groundwater resources and to serve as a forum for groundwater information, education, and advocacy. GRA's primary objectives and purposes include:

- ♦ Promote professional development of scientists, engineers, and others involved in the assessment, development, quality and management of the state's groundwater resources
- ♦ Disseminate scientific and technical information among GRA members and those who influence policy development concerning groundwater resources
- ♦ Develop scientific educational programs that promote the understanding and implementation of groundwater assessment, protection, and management
- ♦ Facilitate the development of alternative technologies and standardization of methods to advance investigation, management, and protection of California's groundwater resources
- ♦ Assume a leadership role in communicating the needs and values of groundwater-related industry to government officials and the public

Membership:

Regular individual membership in GRA is limited to groundwater professionals—those with some combination of collegiate education and/or professional experience in science, engineering, geology or environmental science related to groundwater. Associate (non-voting) members include citizens, businesses, educators, elected officials, community organizations and agriculture related businesses—people interested in groundwater resources who support the mission of GRA.

Activities with Potential to Address Barriers:

- ♦ Seminars: GRA organizes educational seminars throughout the year covering technological advances, new strategies and recent policy developments in groundwater.
- ♦ Publications: The HydroVisions newsletter brings together technical papers, legislative developments, and coming events of interest to the groundwater professional.
- ♦ Annual Meeting
- ♦ Branch Activities: Local branches meet regularly, feature speakers on current groundwater topics.
- ♦ Legislative Advocacy: The GRA has a full time Legislative Advocate to represent the interests of the members before the state legislature and regulatory agencies.

G.9 Engineering Society Profile: Junior Engineering Technological Society (JETS)

Contact information

1420 King Street, Alexandria, VA 22314-2794
Tel. (703) 548-5387, fax (703) 548-0769
info@jets.org
www.jets.org

History and Purpose

JETS was founded in 1950 and is a non-profit educational organization. Its mission is to educate and inspire young people to consider careers in engineering. JETS works to increase interest and awareness of engineering and technology-based careers—with student competitions, assessment tools, career guidance resources, an e-newsletter, and more—as well as resource materials for parents and counselors. JETS programs excite high school students about careers in engineering and related technical fields and help them understand the critical role engineers play in the world around us. JETS has three full-time staff working out of an office in Alexandria, VA.

JETS' publications include booklets describing engineering professions and an electronic newsletter, Pre-Engineering Times, published monthly from September through May. JETS sponsors a one-day engineering competition (TEAMS®) that over 14,000 students in grades 9-12 participate in, and the organization posts a weekly engineering challenge question on their website. The JETS' National Engineering Design Challenge (NEDC)—an exciting hands-on challenge, requires students to work in teams to combine their science, technology, and communication skills to create useful solutions that empower people with disabilities to enter or advance in the workplace. JETS also produces and distributes the National Engineering Aptitude Search+ (NEAS+), a self-assessment high school students can use to gauge their strengths and weaknesses in knowledge areas used in engineering and technology.

Membership:

JETS is not a membership organization, unless the over 20 affiliated engineering societies and professional organizations are counted as "members." At the higher levels of sponsorship ($1,000 and $1,500), benefits to supporting organizations include an ad in one issue of Pre-engineering Times and (at the highest level) become the subject of a Society Spotlight, which runs in at least one issue of Pre-Engineering Times and is archived on the JETS website. JETS affiliates associated with (or potentially associated with) decentralized wastewater treatment includes the American Society of Civil Engineers, the National Society of Professional Engineers, but not the American Society of Agricultural and Biological Engineers. NOTE: ASABE supports JETS Career Exploration initiative by providing content for JETS Web site and the distribution of discipline specific single-panel brochures. The American Academy of Environmental Engineers has also recently become a JETS Affiliate.

Other numbers that give a sense of JETS' influence include:

- Subscriptions to Pre-Engineering Times: About 6,000 (subscribers who are teachers who distribute the publication to their students may make the number of potential readers much higher)
- Unique hits to the web site each month: 40,000 – 50,000
- Students participating in TEAMS® competitions each year: Nearly 14,000
- Students taking the NEAS+ annually: About 1,000
- Number of monthly hits to the weekly JETS Challenge: 1,000

Activities with Potential to Address Barriers:

JETS reaches an audience of pre-engineers who could be exposed to systems thinking about water management and decentralized wastewater treatment even before their university education begins. If either of these appeals to them, they may choose a university based on the availability of coursework in decentralized systems and may choose a broader selection of water- and planning-related courses. They may also be more receptive to considering decentralized solutions as working engineers. Specific ways to tie into the JETS programs include:

- Sponsor and/or provide content for an issue of Pre-Engineering Times devoted to systems thinking in wastewater treatment, exploring different approaches to wastewater treatment—from onsite systems to plants treating multiple millions of gallons per day—and their influence on water pollution, local hydrology, and land use. Each issue of the Pre-Engineering Times has a theme which all articles are devoted to a portion of. For an issue theme to be attractive, it needs to be something that information is readily available on. If a group of wastewater engineers volunteered to feed information to the Times' editorial staff or were interested in sponsoring the issue, this could increase the likelihood of the issue theme being chosen. JETS could also interview a current engineer in the field in its "Extreme Engineer" column.
- The JETS Challenge is a weekly feature of the website, where an engineering problem and the solution to the previous week's challenge are posted. The challenges are written by Dave Meredith, Associate Professor at the Penn State University-Fayette. Decentralized wastewater engineers could submit questions related to decentralized treatment to the JETS email address, info@jets.org..
- In the TEAMS® program, nearly 14,000 students in grades 9-12 work in teams of four-to-eight students to solve engineering problems using an open book, open note, open discussion format during a one-day, two-part competition held at over 100 sites around the country. Each year's competition has several questions covering multiple engineering disciplines. JETS works with Ohio University to design the questions, and they are always looking for suggestions on problem statements. Anyone wanting to submit a problem statement that touched on decentralized wastewater or systems thinking in water resource engineering could submit it to teams@jets.org.

G.10 National Onsite Wastewater Recycling Association (NOWRA)

Contact Information

Linda Hanifin Bonner, Ph.D., Executive Director
P.O. Box 1270
Edgewater, MD 21037
Phone: 410.798.1697, Fax: 410.798.5741
http://www.nowra.org/

History and Purpose:

NOWRA's mission is "to provide leadership and promote the onsite wastewater treatment and recycling industry through education, training, communication and quality tools to support excellence in performance". Providing education and training programs to professionals within this industry to policy officials, the public, and system owners is the driving force of NOWRA's work. Through education, we provide a leadership role in state and federal legislative initiatives to protect water quality and public health.

Onsite systems provide wastewater treatment to homes, businesses and industrial centers, supporting the municipal wastewater treatment infrastructure. They provide services in urban and rural areas and effectively solve problems found in unusual situations and difficult locations. In this era of fiscal limitations, many cities and towns have difficulties addressing the high costs to expand the capacity of their wastewater treatment facilities or extend lines to urban areas to accommodate growth. As a result, onsite systems now provide more than 40% of the wastewater treatment services to residential areas, communities, shopping centers, and commercial businesses throughout the U.S.

Membership:

NOWRA was founded in 1991 by public health and industry specialists. NOWRA is a 501(C)6, not-for-profit organization supported by a membership of over 3,500 individuals within the onsite industry. Members include service providers, installers, equipment manufacturers, suppliers and distributors; system designers, planners and engineers; regulators and public officials. Membership is comprised of individuals, organized state groups, and businesses.

Activities with Potential to Address Barriers:

- Annual conferences and trade shows
- Onsite Journal often contains articles on decentralized technologies, utility development, etc.
- Board of Directors members are active in speaking on decentralized issues in a variety of forums
- Affiliated state groups (list at http://www.nowra.org/?p=117) may be able to help address barriers at a state or local level
- Model Performance Code? A bit of a stretch, but unified rules for siting/performance/maintenance/ etc. of decentralized might help to address barriers
- Technical Education Program currently includes workshops on:
- A New Paradigm For Onsite Systems – Integrating Planning And Management Into Local And Regional Planning
- Onsite Cluster Systems And Technology – A One-Day Specialty Workshop – The Infrastructure Solution for Small and Rural Communities and Sensitive Environmental Sites
- Drip Distribution Systems for Wastewater Recycling

G.11 Engineering Society Profile: National Society of Professional Engineers (NSPE)

Contact Information

1420 King Street, Alexandria, VA 22314-2794
Tel. (703) 684-2800, fax (703) 836-4875
www.nspe.org

History and Purpose

NSPE was founded in 1934 and, according to its web site, "strengthens the engineering profession by promoting engineering licensure and ethics, enhancing the engineer image, advocating and protecting PEs' legal rights at the national and state levels, publishing news of the profession, providing continuing education opportunities, and much more."

The NSPE now has an annual budget of $6 million and a staff of 49. It lists activity areas as engineering licensure, government relations, professional issues, ethics, legal issues, continuing education, employment, and salaries. NSPE publications include a monthly periodical, Engineering Times; a weekly press review email; and a monthly email update.

Membership:

50,000 members, comprising licensed professional engineers, engineers in training, graduates of ABET-accredited engineering schools, or engineering students.

Activities with Potential to Address Barriers:

- Direct lobbying by staff at the Federal level. NSPE has one staff member who lobbies the federal government, both Congress and the regulatory agencies. The staff member responds to pending legislation and proposed regulations, trying to prevent actions that run contrary to NSPE policies. (The NSPE currently has no policy related to equitable evaluation of wastewater treatment options.) There is also a 13-14 Legislative and Government Affairs Committee which meets twice a year and gives direction on the legislative agenda. For NSPE to become active on Federal issues relating to equitable evaluation of wastewater treatment options, there are two routes: 1) The Legislative and Government Affairs Committee could draft a policy recommendation on decentralized treatment. If the NSPE board approves the policy, then the NSPE lobbyist has a basis for urging Congress or the regulatory agencies to carry out the policy. 2) The Legislative and Government Affairs Committee could direct the lobbyist to work for certain policies related to equitable evaluation of wastewater treatment options.
- Help state societies of professional engineers promote equitable consideration of decentralized. The NSPE has a full-time staff member directed at needs in the states. Her main function is to track legislation and identify legislative trends across states. The NSPE maintains contact with affiliated societies at the state level. The state government relations staff member communicates with state societies, with information about pending legislation and legislative trends flowing both directions. They also maintain a listserv that the executives of the state societies subscribe to. If state societies are interested in continuing education in decentralized, or more uniform regulations across state lines, NSPE could help them with information about what other states are doing. For example, New York State Society of Professional Engineers Inc. (NYSSPE) organizes continuing education programs for town engineers and consulting engineers. Wastewater Technologies, Inc., a decentralized technology company has obtained approval for a 6 PDH credit course entitled, "Decentralized Wastewater Management." These are being hosted and promoted by NYSSPE. NYSSPE also advertises getting course material approved for engineering credits at the Practicing Institute of Engineering, Inc. (www.pie-cpc.org).
- Lobbying through its members, who receive action alerts from the national office 4-5 times per year. The NSPE web site also contains a roundup of news about activities in state legislatures affecting professional engineers.
- Political contributions from their political action committee (PAC). The society runs a PAC that is used for contributions to election campaigns. The amount in the fund fluctuates, and can be up to $30,000 some years, according to Lee White. Some of the funds could be directed toward candidates who support for initiatives that favor the decentralized industry.

- Partner on continuing education courses, e.g., on the various ways that wastewater choices affect sustainability or just on decentralized wastewater treatment. NSPE's members span a variety of engineering disciplines, so they tend to create general-interest courses rather than highly technical courses in, for example, specific approaches to wastewater treatment. One recently created course is the Essentials of Sustainable Design, put together by Malcolm Lewis of CTG Energetics. One of the eight course modules is on water, and the ten slides on wastewater treatment (out of around 70 slides in the module) focus mostly on onsite treatment and potential for reuse. A few slides about the hydrological benefits of infiltrating water at or near point of use, and the dewatering effects of gravity sewers, could be added to the course and maintain the module's level of generality while showing more of the effects of wastewater treatment choice on sustainability. Mary Maul, Director of Education at NSPE, is the person to contact with ideas along these lines. She initiates their continuing education courses and chooses topics through a number of means, including results of a members' needs survey.
- Promote systems thinking about wastewater treatment through the Code of Ethics for Engineers. In January 2006, a clause was added to the code stating, "Engineers shall strive to adhere to the principles of sustainable development in order to protect the environment for future generations." Systems thinking is required to understand the environmental impact of a given action. According to Arthur Schwartz, the NSPE's Deputy Executive Director and General Counsel, the society is planning articles in their magazine, PE, to draw attention to the new clause, as well as educational programs to highlight impact the language will have on our internal policies and engineering practice. Any of these efforts could highlight the importance of systems thinking in general and in wastewater projects in particular.

G.12 National Water Research Institute (NWRI)

Contact Information

10500 Ellis Avenue
P.O. Box 20865
Fountain Valley, CA 92728-0865
Phone: (714) 378-3278, Fax: (714) 378-3375
http://www.nwri-usa.org/

History and Purpose:

A public-private partnership, NWRI was founded in 1991 by a group of Southern Californian water agencies in partnership with the Joan Irvine Smith & Athalie R. Clarke Foundation to promote the protection, maintenance, and restoration of water supplies through the development of cooperative research work. NWRI's mission is to create new sources of water through research and technology and to protect the freshwater and marine environments.

NWRI conducts research in water treatment and monitoring, water-quality assessment, knowledge management, and exploratory research. NWRI is an "institute without walls" and requires that matching funds be provided by joint-venture research partnerships. These partners come from local, state, and federal governments as well as from private industry, public utilities, and universities. Since its inception, NWRI has supported numerous research projects, over 100 peer-reviewed technical publications, over 150 conference presentations, and three U.S. patents.

Membership:

Individuals may make tax-deductible donations in support of NWRI's educational programs and outreach activities, including fellowships and scholarships, community support activities, and water education programs. Corporations may contribute to the Corporate Associate Program—established as a means to link university researchers, utilities, manufacturers, and consultants together in an effort to create opportunities for the practical application of research to solve critical water issues. Funding from the Corporate Associates Program directly supports NWRI's research program, including research projects and activities like conferences and workshops.

Activities with Potential to Address Barriers:

- Extensive publications library on a wide range of water quality/supply/treatment/reuse topics.
- Occasional conferences on topics that the organization feels warrant wider interest in the U.S., such as the use of UV technology for disinfecting drinking water or the use of riverbank filtration as a water purification technique.
- Possible funding source for additional research …perhaps for pilot or test case application. Seems to be focused on Southern California issues (desalination, for instance).

G.13 Water Environment Federation (WEF)

Contact information

Water Environment Federation
601 Wythe Street, Alexandria, VA 22314-1994
Tel. 1-800-666-0206 Fax. 1-703-684-2492
http://www.wef.org/

History and Purpose:

Founded in 1928, the Water Environment Federation is a not-for-profit technical and educational organization with members from varied disciplines who work toward the WEF vision of preservation and enhancement of the global water environment. WEF's vision is the basis for all WEF programs and activities. WEF is governed by a member appointed Board of Trustees acting on behalf of its membership to advance its mission of providing information, education, and resources to water quality professionals and the public.

WEF and its Members:

- research and publish the latest information on wastewater treatment and water quality protection;
- provide technical expertise and training on issues including non-point source pollution, hazardous waste, residuals management and groundwater;
- sponsor conferences and other special events around the world;
- review, testify, and comment on environmental regulations and legislation.

Membership:

The WEF network includes over 32,000 water quality professionals from 76 Member Associations in 30 countries. WEF is a community of professionals who are dedicated to improving water quality around the world. WEF is also a link to vital resources including publications, education and training, networking opportunities, tools, and other benefits.

Activities with Potential to Address Barriers:

- Government affairs involvement:
- WEF provides testimony and congressional briefings on water quality topics
- Submits formal comments prepared by member workgroups on proposed regulations
- WEF holds several educational events to inform WEF members of the latest legislative and regulatory developments
- Conferences:
- WEFTEC (www.weftec.org)
- Specialty conferences (current topics include biosolids, collection systems, water reuse; perhaps one could be added for decentralized?)
- Co-sponsored events
- Training and professional development including workshops, webcasts, and training products like workbooks, study guides, and CD-ROMs
- An extensive range of science and technology resources, including:
- Publications (WER,WE&T (Featuring Operations Forum), Biosolids Technical Bulletin, Industrial Wastewater, Water Environment Laboratory Solutions, Water Environment Regulation Watch, Utility Executive, Watershed & Wet Weather Technical Bulletin, WEF Highlights, Books)
- Technical Information (Glossary of Wastewater Terms, Topical Resource Documents)
- Conference Proceedings
- Discussion Forums (http://www.wef.org/technicaldiscussions/)—there are fora for small systems, nutrient removal, operation/maintenance, and emerging contaminants

G.14 Water Environment Research Foundation (WERF)

Contact information

Water Environment Research Foundation
635 Slaters Lane, Suite 300
Alexandria, VA 22314
Tel: 703-684-2470 Fax: 703-299-0742
Email: werf@werf.org

History and Purpose:

The Water Environment Research Foundation is a nonprofit organization that helps utilities and corporations preserve the water environment and protect human health by providing science and technology research to enhance management of our water resources.

For nearly 20 yearsWERF's uncompromising research has answered the needs of the utilities and municipalities, environmental engineering and consulting firms, government agencies, equipment manufacturers, and industrial organizations that compose its subscriber base. With funding from our subscribers and the federal government, WERF has generated research that has made it a trusted resource that is widely used for water quality, science policy, and management decisions.

WERF's progressive research approach incorporates substantial subscriber involvement. Teams of subscribers, environmental professionals, distinguished scientists, and staff work collaboratively to help select, fund, and manage hundreds of research projects in six program areas: Conveyance Systems; Infrastructure Management; Wastewater Treatment & Reuse; Solids Treatment, Residuals, & Reuse; Stormwater; and Watershed Management & Water Quality.

The investigators who carry out WERF's research represent municipal agencies, academia, government laboratories, and industrial and consulting firms. This rich base of expertise allows for creative and innovative solutions, whether it's a new tool or technology, a how-to guide, or knowledge to inform decision making. Some of the best minds in the water quality community provide peer review of our research to ensure unbiased results that will have a lasting effect on the state of science, water environment, and human health.

Membership:

WERF subscribers are municipal wastewater and stormwater agencies, wastewater equipment manufacturers, operators, consulting firms, corporations, and others who share a commitment to producing cost-effective water quality research.

Activities with Potential to Address Barriers:

Decentralized Systems Research

Following the U.S. Enivronmental Protection Agency's 1997 report "Response to Congress on Use of Decentralized Wastewater Systems," the U.S. EPA's Office of Research and Development began to provide increased funding for decentralized wastewater treatment research. The recipient of this funding was the National Decentralized Water Resources Capacity Development Project (NDWRCDP) which was created to address the need for cost-effective water resource management in rural and suburban areas. Through the guidance of a project steering committee, the NDWRCDP developed a number of research projects that fit within the following four topical areas deemed most critical to advancing the science on decentralized systems:

- environmental science and engineering,
- management and economics,
- regulatory reform, and
- training and education.

Phase 1 of the NDWRCDP was administered by Washington University at St. Louis and was completed in 2006. All of the reports and products that were developed under Phase 1 are available for free to the general public and can be downloaded from the NDWRCDP website www.ndwrcdp.org.

NDWRCDP Phase 2 Administered by WERF

As a continuation of the NDWRCDP efforts, the Water Environment Research Foundation (WERF) is administering Phase 2 of the project and has received more than $7.7

million in grants from U.S. EPA over the past four years to fund research in the four topic areas described above. A Decentralized Systems Advisory Committee (DSAC) that includes WERF and its cooperative partners was formed to help evaluate national needs and provide guidance relative to funding priorities. Additionally, DSAC members may receive a portion of the funds through sub-grants to conduct research and advance the mission of their organization. The DSAC partners are

- National Rural Electric Cooperative Association (NRECA),
- Coalition of Alternative Wastewater Treatment (CAWT),
- Electric Power Research Institute (EPRI),
- Consortium of Institutes for Decentralized Wastewater Treatment (CIDWT), and
- National Onsite Wastewater Recycling Association (NOWRA).

WERF developed a Decentralized Research Advisory Council (DRAC) to determine the annual projects and priorities for research in the environmental science and engineering topic area, while the other three research topic areas have been the focus of the DSAC partners. WERF anticipates funding additional DSAC and DRAC projects in 2007. As products from Phase 2 become available, they will be posted to the NDWRCDP website and WERF websites as appropriate.

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Montgomery Water Works & Sanitary Sewer Board

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