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# **Onsite Wastewater Treatment Systems Manual**

Office of Water  
Office of Research and Development  
U.S. Environmental Protection Agency



## Notice

This document has been reviewed in accordance with U.S. Environmental Protection Agency policy and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

## Foreword

The U.S. Environmental Protection Agency is pleased to publish the “Onsite Wastewater Treatment Systems Manual”. This manual provides up-to-date information on onsite wastewater treatment system (OWTS) siting, design, installation, maintenance, and replacement. It reflects significant advances that the expert community has identified to help OWTSs become more cost-effective and environmentally protective, particularly in small suburban and rural areas.

In addition to providing a wealth of technical information on a variety of traditional and new system designs, the manual promotes a performance-based approach to selecting and designing OWTSs. This approach will enable States and local communities to design onsite wastewater programs that fit local environmental conditions and communities’ capabilities. Further details on the proper management of OWTSs to prevent system failures that could threaten ground and surface water quality will be provided in EPA’s forthcoming “Guidelines for Management of Onsite/Decentralized Wastewater Systems”. EPA anticipates that the performance-based approach to selecting and managing appropriate OWTSs at both the watershed and site levels will evolve as States and communities develop programs based on resources that need protection and improvement.

Robert H. Wayland III, Director  
Office of Wetlands, Oceans and Watersheds

E. Timothy Oppelt, Director  
National Risk Management Research Laboratory



## Table of Contents

Notice .....	ii
Foreword .....	iii
List of Figures .....	vii
List of Tables .....	ix
Acknowledgments .....	xi
Introduction .....	xiii
<b>Chapter 1. Background and use of onsite wastewater treatment systems .....</b>	<b>1-1</b>
1.1 Introduction .....	1-1
1.2 History of onsite wastewater treatment systems .....	1-2
1.3 Regulation of onsite wastewater treatment systems .....	1-3
1.4 Onsite wastewater treatment system use, distribution, and failure rate .....	1-4
1.5 Problems with existing onsite wastewater management programs .....	1-5
1.6 Performance-based management of onsite wastewater treatment systems .....	1-10
1.7 Coordinating onsite system management with watershed protection efforts .....	1-11
1.8 USEPA initiatives to improve onsite system treatment and management .....	1-12
1.9 Other initiatives to assist and improve onsite management efforts .....	1-15
<b>Chapter 2. Management of onsite wastewater treatment systems .....</b>	<b>2-1</b>
2.1 Introduction .....	2-1
2.2 Elements of a successful program .....	2-3
2.3 Types of management entities .....	2-6
2.4 Management program components .....	2-13
2.5 Financial assistance for management programs and system installation .....	2-41
<b>Chapter 3. Establishing treatment system performance requirements .....</b>	<b>3-1</b>
3.1 Introduction .....	3-1
3.2 Estimating wastewater characteristics .....	3-1
3.3 Estimating wastewater flow .....	3-2
3.4 Wastewater quality .....	3-8
3.5 Minimizing wastewater flows and pollutants .....	3-10
3.6 Integrating wastewater characterization and other design information .....	3-20
3.7 Transport and fate of wastewater pollutants in the receiving environment .....	3-20
3.8 Establishing performance requirements .....	3-40
3.9 Monitoring system operation and performance .....	3-53
<b>Chapter 4. Treatment processes and systems .....</b>	<b>4-1</b>
4.1 Introduction .....	4-1
4.2 Conventional systems and treatment options .....	4-2
4.3 Subsurface wastewater infiltration .....	4-2
4.4 Design considerations .....	4-6
4.5 Construction management and contingency options .....	4-34
4.6 Septic tanks .....	4-37
4.7 Sand/media filters .....	4-48
4.8 Aerobic treatment units .....	4-52

## Table of Contents, Cont'd.

### Onsite wastewater treatment systems technology fact sheets

1	Continuous-Flow, Suspended-Growth Aerobic Systems (CFSGAS) .....	TFS-1
2	Fixed-film processes .....	TFS-7
3	Sequencing batch reactor systems .....	TFS-13
4	Effluent disinfection processes .....	TFS-17
5	Vegetated submerged beds and other high-specific-surface anaerobic reactors .....	TFS-23
6	Evapotranspiration and evapotranspiration/infiltration .....	TFS-31
7	Stabilization ponds, FWS constructed wetlands, and other aquatic systems .....	TFS-37
8	Enhanced nutrient removal—phosphorus .....	TFS-41
9	Enhanced nutrient removal—nitrogen .....	TFS-45
10	Intermittent sand/media filters .....	TFS-53
11	Recirculating sand/media filters .....	TFS-61
12	Land treatment systems .....	TFS-71
13	Renovation/restoration of subsurface wastewater infiltration systems (SWIS) .....	TFS-77

### Onsite wastewater treatment systems special issues fact sheets

1	Septic tank additives .....	SIFS-1
2	High-organic-strength wastewaters (including garbage grinders) .....	SIFS-3
3	Water softeners .....	SIFS-7
4	Holding tanks and hauling systems .....	SIFS-9

<b>Chapter 5. Treatment system selection .....</b>	<b>5-1</b>
5.1 Factors for selecting appropriate system design and size .....	5-1
5.2 Design conditions and system selection .....	5-1
5.3 Matching design conditions to system performance .....	5-1
5.4 Design boundaries and boundary loadings .....	5-3
5.5 Evaluating the receiving environment .....	5-9
5.6 Mapping the site .....	5-24
5.7 Developing the initial system design .....	5-24
5.8 Rehabilitating and upgrading existing systems .....	5-32

## Figures

Figure 1-1.	Conventional onsite wastewater treatment system .....	1-1
Figure 1-2.	Typical single-compartment septic tank .....	1-3
Figure 1-3.	Onsite treatment system distribution in the United States .....	1-5
Figure 1-4.	Fate of water discharged to onsite wastewater treatment systems .....	1-7
Figure 1-5.	The watershed approach planning and management cycle .....	1-13
Figure 1-6.	Large-capacity septic tanks and other subsurface discharges .....	1-14
Figure 2-1.	Onsite wastewater management overlay zones example .....	2-18
Figure 2-2.	Process for developing onsite wastewater management .....	2-20
Figure 3-1.	Distribution of mean household daily per capita indoor water use .....	3-5
Figure 3-2.	Indoor water use percentage, including leakage, for 1,188 data logged homes .....	3-6
Figure 3-3.	Daily indoor water use pattern for single-family residence .....	3-7
Figure 3-4.	Peak wastewater flows for single-family home .....	3-8
Figure 3-5.	Average hourly distribution of total unfiltered BOD <sub>5</sub> .....	3-10
Figure 3-6.	Typical graywater reuse approach .....	3-19
Figure 3-7.	Strategy for estimating wastewater flow and composition .....	3-21
Figure 3-8.	Plume movement through the soil to the saturated zone .....	3-22
Figure 3-9.	An example of effluent plume movement .....	3-25
Figure 3-10.	Soil treatment zones .....	3-26
Figure 3-11.	Zinc sorption by clay as a function of pH .....	3-38
Figure 3-12.	Example of compliance boundaries for onsite wastewater treatment systems .....	3-40
Figure 3-13.	Input and output components of the MANAGE assessment method .....	3-44
Figure 3-14.	Probability of environmental impact decision tree .....	3-50
Figure 4-1.	Conventional subsurface wastewater infiltration system .....	4-2
Figure 4-2.	Lateral view of conventional SWIS-based system .....	4-5
Figure 4-3.	Subsurface infiltration system design versus depth to a limiting condition .....	4-7
Figure 4-4.	Raising the infiltration surface with a typical mound system .....	4-9
Figure 4-5.	Schematic of curtain drain construction .....	4-9
Figure 4-6.	Capacity chart for subsurface drains .....	4-11
Figure 4-7.	Pathway of subsoil reaeration .....	4-16
Figure 4-8.	Distribution box with adjustable weir outlets .....	4-19
Figure 4-9.	Serial relief line distribution network and installation detail .....	4-19
Figure 4-10.	Drop box distribution network .....	4-21

## Figures, Cont'd.

Figure 4-11.	Various gravelless systems .....	4-21
Figure 4-12.	Placement of leaching chambers in typical application .....	4-22
Figure 4-13.	Typical pressurized distribution system layout .....	4-23
Figure 4-14.	Pressure manifold detail .....	4-24
Figure 4-15.	Horizontal design for pressure distribution .....	4-25
Figure 4-16.	Rigid pipe pressure distribution networks with flushing cleanouts .....	4-26
Figure 4-17.	Pressure manifold and flexible drip lines prior to trench filling .....	4-28
Figure 4-18.	Emitter discharge rates versus in-line pressure .....	4-29
Figure 4-19.	Dripline layout on a site with trees .....	4-31
Figure 4-20.	Pumping tank (generic) .....	4-32
Figure 4-21.	Profile of a single-compartment septic tank with outlet screen .....	4-38
Figure 4-22.	Two-compartment tank with effluent screen and surface risers .....	4-40
Figure 4-23.	Examples of septic tank effluent screens/filters .....	4-41
Figure 4-24.	Tongue and groove joint and sealer .....	4-43
Figure 4-25.	Underdrain system detail for sand filters .....	4-48
Figure 4-26.	Schematics of the two most common types of sand media filters .....	4-50
Figure 5-1.	Preliminary design steps and considerations .....	5-2
Figure 5-2.	Performance (design) boundaries associated with onsite treatment systems .....	5-4
Figure 5-3.	Subsurface wastewater infiltration system design/performance boundaries .....	5-5
Figure 5-4.	Effluent mounding effect above the saturated zone .....	5-8
Figure 5-5.	General considerations for locating a SWIS on a sloping site .....	5-13
Figure 5-6.	Landscape position features (see table 5-6 for siting potential) .....	5-14
Figure 5-7.	Conventional system layout with SWIS replacement area .....	5-15
Figure 5-8.	Site evaluation/site plan checklist .....	5-16
Figure 5-9.	Soil textural triangle .....	5-19
Figure 5-10.	Types of soil structure .....	5-20
Figure 5-11.	Potential evaporation versus mean annual precipitation .....	5-24
Figure 5-12.	Development of the onsite wastewater system design concept .....	5-25
Figure 5-13.	Onsite wastewater failure diagnosis and correction procedure .....	5-33

## Tables

Table 1-1.	Typical pollutants of concern from onsite wastewater treatment systems .....	1-2
Table 1-2.	Census of housing tables: sewage disposal, 1990 .....	1-6
Table 1-3.	Estimated onsite treatment system failure rates in surveyed states .....	1-7
Table 2-1.	Organizational approaches for managing onsite systems .....	2-7
Table 2-2.	Survey of state certification and licensing programs .....	2-33
Table 2-3.	Components of an onsite system regulatory program .....	2-36
Table 2-4.	Compliance assurance approaches .....	2-38
Table 2-5.	Example of functional responsibilities matrix .....	2-42
Table 2-6.	Funding options .....	2-43
Table 2-7.	Advantages and disadvantages of various funding sources .....	2-47
Table 3-1.	Summary of average daily residential wastewater flows .....	3-3
Table 3-2.	Comparison of daily per capita indoor water use for 12 study sites .....	3-4
Table 3-3.	Residential water use by fixture or appliance .....	3-5
Table 3-4.	Typical wastewater flow rates from commercial sources .....	3-7
Table 3-5.	Typical wastewater flow rates from institutional sources .....	3-8
Table 3-6.	Typical wastewater flow rates from recreational facilities .....	3-9
Table 3-7.	Constituent mass loadings and concentrations .....	3-11
Table 3-8.	Residential wastewater pollutant contributions by source .....	3-11
Table 3-9.	Wastewater flow reduction methods .....	3-13
Table 3-10.	Flow rates and flush volumes before and after U.S. Energy Policy Act .....	3-14
Table 3-11.	Wastewater flow reduction: water-carriage toilets and systems .....	3-14
Table 3-12.	Wastewater flow reduction: non-water-carriage toilets .....	3-15
Table 3-13.	Wastewater flow reduction: showering devices and systems .....	3-15
Table 3-14.	Wastewater flow reduction: miscellaneous devices and systems .....	3-16
Table 3-15.	Reduction in pollutant loading achieved by eliminating garbage disposals .....	3-18
Table 3-16.	Typical wastewater pollutants of concern .....	3-23
Table 3-17.	Examples of soil infiltration system performance .....	3-23
Table 3-18.	Case study: septic tank effluent and soil water quality .....	3-28
Table 3-19.	Wastewater constituents of concern and representative concentrations .....	3-29
Table 3-20.	Waterborne pathogens found in human waste and associated diseases .....	3-32
Table 3-21.	Typical pathogen survival times at 20 to 30 °C .....	3-33
Table 3-22.	MCLs for selected organic chemicals in drinking water .....	3-35
Table 3-23.	Case study: concentration of metals in septic tank effluent .....	3-36
Table 3-24.	MCLs for selected inorganic chemicals in drinking water .....	3-37
Table 3-25.	Treatment performance requirements for New Shoreham, Rhode Island .....	3-45

## Tables, Cont'd.

Table 3-26.	Resource listing, value ranking, and wastewater management schematic .....	3-46
Table 3-27.	Proposed onsite system performance standards in various control zones .....	3-48
Table 3-28.	Treatment performance standards in various control zones .....	3-48
Table 3-29.	Nitrogen loading values used in the Buttermilk Bay assessment .....	3-52
Table 3-30.	Typical laboratory costs for water quality analysis .....	3-61
Table 4-1.	Commonly used treatment processes and optional treatment methods .....	4-3
Table 4-2.	Characteristics of typical SWIS applications .....	4-5
Table 4-3.	Suggested hydraulic and organic loading rates for sizing infiltration surfaces .....	4-12
Table 4-4.	Geometry, orientation, and configuration considerations for SWISs .....	4-16
Table 4-5.	Distribution methods and applications .....	4-18
Table 4-6.	Dosing methods and devices .....	4-23
Table 4-7.	Pressure manifold sizing .....	4-25
Table 4-8.	Contingency options for SWIS malfunctions .....	4-34
Table 4-9.	Operation, maintenance, and monitoring activities .....	4-36
Table 4-10.	Characteristics of domestic septic tank effluent .....	4-38
Table 4-11.	Average septic tank effluent concentrations for selected parameters .....	4-39
Table 4-12.	Average septic tank effluent concentrations from various commercial establishments .....	4-39
Table 4-13.	Septic tank capacities for one- and two-family dwellings .....	4-40
Table 4-14.	Watertightness testing procedure/criteria for precast concrete tanks .....	4-43
Table 4-15.	Chemical and physical characteristics of domestic septage .....	4-46
Table 4-16.	Single pass and recirculating filter performance .....	4-53
Table 5-1.	Types of mass loadings to subsurface wastewater infiltration systems .....	5-6
Table 5-2.	Potential impacts of mass loadings on soil design boundaries .....	5-7
Table 5-3.	Types of mass loadings for point discharges to surface waters .....	5-9
Table 5-4.	Types of mass loadings for evapotranspiration systems .....	5-9
Table 5-5.	Site characterization and assessment activities for SWIS applications .....	5-11
Table 5-6.	SWIS siting potential vs. landscape position features .....	5-14
Table 5-7.	Practices to characterize subsurface conditions through test pit inspection .....	5-18
Table 5-8.	Example of a total cost summary worksheet to compare alternatives .....	5- 31
Table 5-9.	Common onsite wastewater treatment system failures .....	5-32
Table 5-10.	General OWTS inspection and failure detection process .....	5-35
Table 5-11.	Response of corrective actions on SWIS boundary mass loadings .....	5-35

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This update of the 1980 *Design Manual: Onsite Wastewater Treatment and Disposal Systems* (see <http://www.epa.gov/ncepihom/nepishom/tips.html>) was developed to provide supplemental and new information for wastewater treatment professionals in both the public and private sectors. This manual is not intended to replace the previous manual, but rather to further explore and discuss recent developments in treatment technologies, system design, and long-term system management.

The information in the chapters that follow is provided in response to several calls for a more focused approach to onsite wastewater treatment and onsite system management. Congress has expressed interest in the status of site-level approaches for treating wastewater, and the Executive Branch has issued directives for moving forward with improving both the application of treatment technologies and management of the systems installed.

The U.S. Environmental Protection Agency (USEPA) responded to this interest by convening a team of subject matter experts from public agencies, private organizations, professional associations, and the academic community. Two representatives from the USEPA Office of Water and a representative from the Office of Research and Development coordinated the project team for this document. Close coordination with the USEPA Office of Wastewater Management and other partners at the federal, state, and local levels helped to ensure that the information in this manual supports and complements other efforts to improve onsite wastewater management across the nation.

The principal authors of the document are Richard Otis of Ayres Associates; Jim Kreissl, Rod Frederick, and Robert Goo of USEPA; Peter Casey of the National Small Flows Clearinghouse; and Barry Tanning of Tetra Tech, Inc. Other persons who made significant contributions to the manual include Robert Siegrist of the Colorado School of Mines; Mike Hoover of North Carolina State University; Jean Caudill of the Ohio Department of Health; Bob Minicucci of the New Hampshire Department of Environmental Services; Tom Groves of the New England Interstate Water Pollution Control Commission; Tom Yeager of Kennedy/Jenks Consultants; Robert Rubin of North Carolina State University; Pio Lombardo of Lombardo Associates; Dov Weitman and Joyce Hudson of USEPA; Lisa Brown, Seldon Hall, Richard Benson, and Tom Long of the Washington Department of Health; David Pask and Tricia Angoli of the National Small Flows Clearinghouse; James Davenport of the National Association of Counties; Jim Watson of the Tennessee Valley Authority; John Austin of the U.S. Agency for International Development; Pat Fleming of the U.S. Bureau of Land Management; James Jacobsen of the Maine Department of Human Services; Richard Barror of the Indian Health Service; Glendon Deal of the U.S. Department of Agriculture; Lisa Knerr, Jonathan Simpson, and Kay Rutledge of Tetra Tech; Kenneth Pankow of Pankow Engineering; Linda Stein of Eastern Research Group; Robert Adler, Charles Pycha, Calvin Terada, and Jonathon Williams of USEPA Region 10; Richard Carr of the World Health Organization; Ralph Benson of the Clermont County, Ohio, General Health District; Rich Piluk of the Anne Arundel, Maryland, county government; Jerry Nonogawa of the Hawaii Department of Health; Tony Smithson of the Lake County, Illinois, Health Department; Conrad G. Keyes, Jr., and Cecil Lue-Hing of the EWRI of ASCE; Robert E. Lee of the National Onsite Wastewater Recycling Association; Anish Jantrania, private consultant; Larry Stephens of Stephens Consultants; Bruce Douglass and Bill Heigis of Stone Engineering; Alan Hassett of Oak Hill Co.; Steven Braband of Biosolutions, Inc.; Matt Byers of Zoeller Co.; Carl Thompson, Infiltrator Systems, Inc.; Alex Mauck of EZ Drain; Bob Mayer of American Manufacturing; Rodney Ruskin of Geoflow; Fred Harned of Netafim; Don Canada of the American Decentralized Wastewater Association, and Michael Price, Norweco, Inc.

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## Review Team Members for the Onsite Wastewater Treatment Systems Manual

Robert Goo, USEPA, Office of Wetlands (OW), Oceans and Watersheds

Rod Frederick, USEPA, OW, Oceans and Watersheds

Eric Slaughter, USEPA, OW, Oceans and Watersheds

Jim Kreissl, USEPA, Office of Research and Development (ORD)

Don Brown, USEPA, ORD

Robert Bastian, USEPA, Office of Wastewater Management (OWM)

Charlie Vanderlyn, USEPA, OWM

Steve Hogue, USEPA, OWM

Joyce Hudson, USEPA, OWM

Joel Salter, USEPA, Office of Science and Technology

Philip Berger, USEPA, Office of Ground Water and Drinking Water (OGWDW)

Howard Beard, USEPA, OGWDW

Robert Adler, USEPA Region 1

Charles Pycha, USEPA Region 5

Ernesto Perez, USEPA Region 6

Calvin Terada, USEPA Region 10

Danny Averett, U.S. Army Corps of Engineers

Ed Smith, USACE Research Laboratory

Rick Scholz, USACE Research Laboratory

John Austin, U.S. Agency for International Development

Patrick Fleming, National Park Service

Rick Barror, U.S. Public Health Service

Gary Morgan, USDA Rural Development Administration

Andree Duvarney, USDA Natural Resources Conservation Service

Phil Mummert, Tennessee Valley Authority

Raymond Reid, Pan American Health Organization

Homero Silva, Organización Mundial de la Salud, Costa Rica

Dennis Warner, World Health Organization

Tom Groves, New England Interstate Water Pollution Control Commission

Paul Chase, DuPage County (Illinois) Health Department

Douglas Ebelherr, Illinois Department of Public Health

Randy Clarkson, Missouri Department of Natural Resources

Anish Janrania, Virginia Department of Health

Steve Steinbeck, North Carolina Department of Health and Natural Resources

Ron Frey, Arizona Department of Environmental Quality

Mark Soltman, Washington State Department of Health

Alex Campbell, Ontario Ministry of Environment and Approvals

Jerry Tyler, University of Wisconsin

Mike Hoover, North Carolina State University

Ruth Alfasso, Massachusetts Department of Environmental Protection

Jerry Nunogawa, Hawaii Department of Health

Robert Siegrist, Colorado School of Mines

Rick Piluk, Anne Arundel County (Maryland) Health Department

Gary Eckler, Erie County (Ohio) Sanitary Engineering Department

Janet Rickabaugh, Clermont County (Ohio) Health District

Jay Harrell, Mohave County (Arizona) Environmental Health Division

Dan Smith, Coconino County (Arizona) Environmental Health Services

Tom Yeager, Kennedy/Jenks Consultants

Richard Otis, Ayres Associates

Robert Mayer, American Manufacturing Co.

Hamilton Brown, National Association of Towns and Townships

Larry Markham, National Environmental Health Association

Robert Rubin, Water Environment Federation

Thomas McLane, American Society of Civil Engineers

Dan MacRitchie, American Society of Civil Engineers

Don Canada, American Decentralized Wastewater Association

Naomi Friedman, National Association of Counties

Peter Casey, National Small Flows Clearinghouse

Tricia Angoli, national Small Flows Clearinghouse

Thomas Bruursema, National Sanitation Foundation

## Introduction

### Background and Purpose

The U.S. Environmental Protection Agency (USEPA) first issued detailed guidance on the design, construction, and operation of onsite wastewater treatment systems (OWTSs) in 1980. *Design Manual: Onsite Wastewater Treatment and Disposal Systems* (USEPA, 1980) was the most comprehensive summary of onsite wastewater management since the U.S. Public Health Service had published a guidance on septic tank practice in 1967 (USPHS, 1967). The 1980 manual focused on both treatment and “disposal” of wastewater in general accordance with the approach and terminology in use at the time. The 1980 design manual stressed the importance of site-specific soil, landscape, ground water, and effluent characterization and included soil percolation tests as one of several site evaluation tools to be used in system design and placement. The manual’s discussion of water conservation to reduce hydraulic flows, pollutant reduction to minimize contaminant loading, and management programs to oversee the full range of treatment activities was especially important to the developing field of onsite wastewater treatment in the United States and other countries.

Technologies explored in the 1980 manual include the conventional system (a septic tank with a subsurface wastewater infiltration system), alternating leach fields, uniform distribution systems, intermittent sand filters, aerobic units, disinfection technologies, and evapotranspiration systems. The original manual also contains guidance on dosing chambers, flow diversion methods for alternating beds, nutrient removal, and disposal of residuals. Although much of that information is still useful, advances in regional planning, improvements in ground water and surface water protection, and new technologies and management concepts necessitate further guidance for public health districts, water quality agencies, planning boards, and other audiences. In addition, the growing national emphasis on management programs that establish performance requirements rather than prescriptive codes for the design, siting, installation, operation, and maintenance of onsite systems underscores the importance of revising the manual to

address these emerging issues in public health and water resource protection.

USEPA is committed to elevating the standards for onsite wastewater management practice and removing barriers that preclude widespread acceptance of onsite treatment technologies. The purpose of this update of the 1980 manual is to provide more comprehensive information on management approaches, update information on treatment technologies, and describe the benefits of performance-based approaches to system design. The management approaches suggested in this manual involve coordinating onsite system planning and management activities with land use planning and watershed protection efforts to ensure that the impacts of onsite wastewater systems are considered and controlled at the appropriate scale. The management approaches described in this manual support and are consistent with USEPA’s draft *Guidelines for Management of Onsite/Decentralized Wastewater Systems* (USEPA, 2000). The incorporation of performance standards for management programs and for system design and operation can help ensure that no onsite system alternative presents an unacceptable risk to public health or water resources.

This manual contains overview information on treatment technologies, installation practices, and past performance. It does not, however, provide detailed design information and is not intended as a substitute for region- and site-specific program criteria and standards that address conditions, technologies, and practices appropriate to each individual management jurisdiction. The information in the following chapters provides an operational framework for developing and improving OWTS program structure, criteria, alternative designs, and performance requirements. The chapters describe the importance of planning to ensure that system densities are appropriate for prevailing hydrologic and geologic conditions, performance requirements to guide system design, wastewater characterization to accurately predict waste strength and flows, site evaluations that identify appropriate design and performance boundaries, technology selection to

ensure that performance requirements are met, and management activities that govern installation, operation, maintenance, and remediation of failed systems.

This manual is intended to serve as a technical guidance for those involved in the design, construction, operation, maintenance, and regulation of onsite systems. It is also intended to provide information to policy makers and regulators at the state, tribal, and local levels who are charged with responsibility for developing, administering, and enforcing wastewater treatment and management program codes. The activities and functions described herein might also be useful to other public health and natural resource protection programs. For example, properly planned, designed, installed, operated, and maintained onsite systems protect wellhead recharge areas, drinking water sources, watershed, estuaries, coastal zones, aquatic habitat, and wetlands.

Finally, this manual is intended to emphasize the need to improve cooperation and coordination among the various health, planning, zoning, development, utility, and resource protection programs operated by public and private organizations. A watershed approach to protecting public health and environmental resources requires an integrated operational framework that encourages independent partners to function cooperatively while each retains the ability to satisfy internal programmatic and management objectives. Integrating onsite wastewater management processes with other activities conducted by public and private entities can improve both the effectiveness and the efficiency of efforts to minimize the risk onsite systems might present to health and ecological resources.

## **Overview**

Onsite wastewater treatment systems collect, treat, and release about 4 billion gallons of treated effluent per day from an estimated 26 million homes, businesses, and recreational facilities nationwide (U.S. Census Bureau, 1997). These systems, defined in this manual as those serving fewer than 20 people, include treatment units for both individual buildings and small clusters of buildings connected to a common treatment system. Recognition of the impacts of onsite systems on ground water and surface water quality (e.g., nitrate and bacteria contamination, nutrient inputs to surface waters) has increased interest in optimizing the systems' performance. Public health and environmental protection officials now acknowledge that onsite systems are not just

temporary installations that will be replaced eventually by centralized sewage treatment services, but permanent approaches to treating wastewater for release and reuse in the environment. Onsite systems are recognized as potentially viable, low-cost, long-term, decentralized approaches to wastewater treatment if they are planned, designed, installed, operated, and maintained properly (USEPA, 1997). NOTE: In addition to existing state and local oversight, decentralized wastewater treatment systems that serve more than 20 people might become subject to regulation under the USEPA's Underground Injection Control Program, although EPA has proposed not to include them (64FR22971:5/7/01).

Although some onsite wastewater management programs have functioned successfully in the past, problems persist. Most current onsite regulatory programs focus on permitting and installation.

Few programs address onsite system operation and maintenance, resulting in failures that lead to unnecessary costs and risks to public health and water resources. Moreover, the lack of coordination among agencies that oversee land use planning, zoning, development, water resource protection, public health initiatives, and onsite systems causes problems that could be prevented through a more cooperative approach. Effective management of onsite systems requires rigorous planning, design, installation, operation, maintenance, monitoring, and controls.

## **Public health and water resource impacts**

State and tribal agencies report that onsite septic systems currently constitute the third most common source of ground water contamination and that these systems have failed because of inappropriate siting or design or inadequate long-term maintenance (USEPA, 1996a). In the 1996 Clean Water Needs Survey (USEPA, 1996b), states and tribes also identified more than 500 communities as having failed septic systems that have caused public health problems. The discharge of partially treated sewage from malfunctioning onsite systems was identified as a principal or contributing source of degradation in 32 percent of all harvest-limited shellfish growing areas. Onsite wastewater treatment systems have also contributed to an overabundance of nutrients in ponds, lakes, and coastal estuaries, leading to the excessive growth of algae and other nuisance aquatic plants (USEPA, 1996b). In addition, onsite systems contribute to contamination of drinking water sources. USEPA estimates that 168,000 viral illnesses and 34,000 bacterial illnesses occur each year as a result of con-

sumption of drinking water from systems that rely on improperly treated ground water. Malfunctioning septic systems have been identified as one potential source of ground water contamination (USEPA, 2000).

### **Improving treatment through performance requirements**

Most onsite wastewater treatment systems are of the conventional type, consisting of a septic tank and a subsurface wastewater infiltration system (SWIS). Site limitations and more stringent performance requirements have led to significant improvements in the design of wastewater treatment systems and how they are managed. Over the past 20 years the OWTS industry has developed many new treatment technologies that can achieve high performance levels on sites with size, soil, ground water, and landscape limitations that might preclude installing conventional systems. New technologies and improvements to existing technologies are based on defining the performance requirements of the system, characterizing wastewater flow and pollutant loads, evaluating site conditions, defining performance and design boundaries, and selecting a system design that addresses these factors.

Performance requirements can be expressed as numeric criteria (e.g., pollutant concentration or mass loading limits) or narrative criteria (e.g., no odors or visible sheen) and are based on the assimilative capacity of regional ground water or surface waters, water quality objectives, and public health goals. Wastewater flow and pollutant content help define system design and size and can be estimated by comparing the size and type of facility with measured effluent outputs from similar, existing facilities. Site evaluations integrate detailed analyses of regional hydrology, geology, and water resources with site-specific characterization of soils, slopes, structures, property lines, and other site features to further define system design requirements and determine the physical placement of system components.

Most of the alternative treatment technologies applied today treat wastes after they exit the septic tank; the tank retains settleable solids, grease, and oils and provides an environment for partial digestion of settled organic wastes. Post-tank treatment can include aerobic (with oxygen) or anaerobic (with no or low oxygen) biological treatment in suspended or fixed-film reactors, physical/chemical treatment, soil infiltration, fixed-media filtration, and/or disinfection. The application and sizing of treatment units based on these technologies are defined by perfor-

mance requirements, wastewater characteristics, and site conditions.

### **Toward a more comprehensive approach**

The principles of the 1980 onsite system design manual have withstood the test of time, but much has changed over the past 20 years. This manual incorporates much of the earlier guide but includes new information on treatment technologies, site evaluation, design boundary characterization, and especially management program functions. The manual is organized by functional topics and is intended to be a comprehensive reference. Users can proceed directly to relevant sections or review background or other information (see Contents).

Although this manual focuses on individual and small, clustered onsite systems, state and tribal governments and other management entities can use the information in it to construct a framework for managing new and existing large-capacity decentralized systems (those serving more than 20 people), subject to regulation under state or local Underground Injection Control (UIC) programs. The UIC program was established by the Safe Drinking Water Act to protect underground sources of drinking water from contamination caused by the underground injection of wastes. In most parts of the nation, the UIC program, which also deals with motor vehicle waste disposal wells, large-capacity cesspools, and storm water drainage wells, is managed by state or tribal water or waste agencies with authority delegated by USEPA.

The Class V UIC program and the Source Water Protection Program established by the 1996 amendments to the federal Safe Drinking Water Act are bringing federal and state drinking water agencies into the field of onsite wastewater treatment and management. Both programs will likely require more interagency involvement and cooperation to characterize wastewater impacts on ground water resources and to develop approaches to deal with real or potential problems. States currently have permit-by-rule provisions for large-capacity septic systems.

### **Overview of the revised manual**

The first two chapters of this manual present overview and management information of special interest to program administrators. Chapters 3, 4, and 5 contain technical information on wastewater characterization, site evaluation and selection, and treatment technologies and how to use them in develop-

ing a system design. Those three chapters are intended primarily for engineers, soil scientists, permit writers, environmental health specialists, site evaluators, and field staff. Summaries of all the chapters appear below. The level of detail provided in this manual is adequate for preliminary

system design and development of a management program. References are provided for additional research and information on how to incorporate local characteristics into an optimal onsite management program.

### **Overview of the Onsite Wastewater Treatment Systems Manual**

Chapter 1, Background and use of onsite wastewater treatment systems	Review of the history and current use of onsite treatment systems, introduction of management concepts, and brief discussion of alternative technologies.
Chapter 2, Management and regulation of onsite wastewater treatment systems	Discussion of methods to plan, institutionalize, and manage OWTS programs, including both prescriptive and performance-based approaches. If prescriptive-based management programs are used, parts of this chapter will not apply because the basic functions of prescriptive-based management are more simplified.
Chapter 3, Establishing treatment system performance requirements	Discussion of methods for estimating wastewater flow and composition, identifying pollutants of concern and their transport and fate in the environment, establishing performance requirements, and estimating watershed-scale impacts.
Chapter 4, Treatment processes and systems	Identification of conventional and alternative OWTS technologies, pollutant removal effectiveness, design parameters, operation and maintenance requirements, costs, and special issues.
Chapter 5, Treatment system selection	Discussion of strategies for establishing site-specific performance requirements and performance boundaries based on wastewater flow and composition and site characteristics, selection of treatment alternatives, and analysis of system failure and repair or replacement alternatives.
Glossary	Definitions of terms used in the manual.
Resources	Selected reference documents and Internet resources.