# SITE CHARACTERIZATION AND DESIGN OF

# On-Site Septic Systems

M. S. Bedinger, J. S. Fleming,
and A. I. Johnson, editors

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# *Site Characterization and Design of On-Site Septic Systems*

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# Foreword

This publication, *Site Characterization and Design of On-Site Septic Systems,* contains papers presented at the symposium of the same name held in New Orleans, LA on 16–17 Jan. 1997. The symposium was sponsored by ASTM Committee D18 on Soil and Rock, the National Onsite Wastewater Recycling Association (NOWRA), and the U.S. Environmental Protection Agency. M. S. Bedinger, Consulting Hydrogeologist; J. S. Fleming, Polaris Engineering, Inc.; and A. I. Johnson, A. Ivan Johnson, Inc., presided as symposium cochairmen and are coeditors of the resulting publication.

# Overview

It is estimated that 25% of the U.S. population use septic systems for treatment and disposal of their household sewage. The on-site septic system technology is undergoing dramatic changes and advances with increased effort and thought being placed on the effective and economical design of on-site systems. ASTM Committee D18 on Soil and Rock has for many years been concerned about the quality and quantity of the ground water or of any other fluids contained in or moving through soil and rock voids. The initiation in 1991 of Section D18.01.06 on On-Site Waste Treatment and Disposal is a continuation of the recognition by ASTM for the need to establish industry consensus standards concerning the design and operation of on-site waste systems.

In accordance with the objectives of ASTM Subcommittee D18.01 on Surface and Subsurface Characterization and in cooperation with the U.S. Environmental Protection Agency (EPA) and the National Onsite Wastewater Recycling Association (NOWRA) a one-and-one-half-day symposium on on-site septic systems was held in New Orleans, Louisiana on 16 and 17 Jan. 1997. This ASTM publication presents papers from this symposium. The symposium consisted of three half-day sessions. The subjects of the sessions were Septic System Operation and Evaluation, Septic System Site Characterization and Design, and Alternative Systems and Component Design.

The opening paper of the symposium (not in this volume) by **Johnson and Bedinger** presented an overview of the activities and scope of work completed and in progress by Section D18.01.06. The title and scope of the three standards completed by Section D18.01.06 are given in Appendix A. Appendix B is a list of terms defined in the three standards. Appendix C is a list of ASTM standards related to on-site septic system components, design of systems, or standards useful for characterization of sites for septic systems. These appendices can be found at the end of this Overview.

## Septic System Operation and Evaluation

A comprehensive inspection procedure for evaluation of septic systems in Minnesota was reviewed in the paper by **Frekot and Elvebak.** Distribution box performance was evaluated by **Gross, Peetz, Hearne, and Rutledge** to show that they are ineffective for distributing wastewater equally along the soil absorption trenches, even with dosing and with flow equalization products in use. The infiltration of wastewater from drainfields was shown to be significantly reduced by reduced soil hydraulic conductivity by the introduction of high sodium detergents used in the home by **Patterson.**

An evaluation of pressurized distribution systems in Maryland led to recommended procedures for increased maintenance and inspection and revision in design of the systems as reported by **Glotfelty, Hammerlund, and Prager.** The use of low-pressure distribution systems were used to provide even distribution of septic tank effluent in septic filter fields. The study by **Gross, Rutledge, Wolf, and Bomblat** found that a simple pump timer and counter provide information for maintenance of the pressurized laterals.

Surface irrigation by applying wastewater to agricultural and nonagricultural lands has proved to be a viable option to surface water discharge and subsurface disposal. **Woody, Rubin, and Frederick** report that successful system operation hinges on accurate soil and site investigations, suitable agronomic receiver sites, proper design of wastewater treatment methods and components, and an understanding of disposal methods. **Owens, Rutledge, Roark, Gross, Wolf, and McNew** conducted research to determine the hydraulic performance of a serially flooded filter field with time, finding that hydraulic failure of the soil did not occur, but that blockage formed in the pipes in the trenches.

### Septic System Site Characterization and Design

The Massachusetts soil evaluator program is discussed by **Veneman and Fletcher** that is designed to meet the new on-site sewage regulations requiring training and examination of soil evaluators. **Winkler and Feiden** present a pressure system design spreadsheet that enables designers to configure asymmetrical systems with up to 26 laterals and 50 orifices per lateral. Output from the spreadsheet includes system discharge, head losses for the delivery pipe, manifold, laterals, lateral segments, and total system losses, pump capability, and system configuration details. Codes governing the design of individual sewage septic systems were developed under the assumption that systems were to be placed in natural soils. In their paper, **Wespetal and Schirmers** describe the problems associated with disturbed soils, the methods of proper field identification, how to quantify the extent of disturbance, and provide design options to overcome these limitations.

A study by **Townshend** showed that manmade materials can be used effectively to produce high-quality effluent in an experimental installation using biotextile and geodrain materials in separate recirculating nitrification-denitrification filters and polishing filters. Methods for measuring saturated hydraulic conductivity of soils in the vadose are reviewed and compared with the constant-head well permeameter method by **Amoozegar. Hart** proposed that both infiltrative capacity of the soil and the evaporative capacity of the climate be combined in design to minimize the drainfield size. In their paper, **Rutledge, Owens, Goff, Gross, Brumbelow, and Wolf** provide an alternative procedure for design of systems in which effluent loading is limited by the crust which forms at the gravel-soil interface.

An empirical procedure for analysis of mounding in the vadose zone in the evaluation of the viability of large septic systems is given by **Amoozegar and Martin. Townshend, Jowett, LeCraw, Waller, Paloheimo, Ives, Russell, and Liefhebber** report on the design of self-contained water supply, water treatment, and water reuse facilities for two adjoining houses built on small unserviced lots to demonstrate the feasibility of being completely "unplugged" from public hydro, sewer, and water supply.

### Alternative Systems and Component Design

Discussing a standard modular design, **Ball and Denn** show that the recirculating sand filter is a successful wastewater treatment system for producers of small to medium (500 to 1 000 000 gal/day) wastewater flows. In their paper, **Burnell and McOmber** summarize a study to determine the suitability of used tires as a substitute for drainfield aggregate in standard sewage disposal systems and as a substitute for gravelless domed chamber systems. The study showed evidence of leaching of iron, zinc, and sulfate from used tie chips, but gravelless domed chambers using half ties appears to be more promising.

**Bounds** estimates that more than 45% of ultimate treatment can be accomplished in the septic tank in discussing the properties of an efficient septic tank as the primary treatment component for an on-site wastewater collection and treatment system. **Nichols, Wolf, Gross, and Rutledge** evaluated the renovation of chemical and biological components of septic tank effluent in a newly constructed stratified sand filter. The study concluded that a sand filter can be used to renovate septic tank effluent when soils are not conducive to the use of traditional leach fields.

**Dix and May** review the field performance of chamber leaching systems and report that several field studies support the performance claim for chamber systems. **Jowett** reports on a new type of free-draining biofilter to treat domestic septic tank effluent. **Tyre and Dennis** relate alternative design for wastewater treatment for a subdivision in an area of high watertable.

The evaporative capacity of the climate is used in the system described by **Church** in the area east of the Front Range in Colorado. The drip irrigation system of Church uses a treatment and dispersal system with multiple low-pressure drainfields lines, with provision for periods of nonuse and recovery of selected drainfield lines.

# APPENDIX A

Three ASTM standard practices have been prepared by Section D18.21.01.06 on Treatment and Disposal of On-Site Waste. These standards are ASTM Practice for Surface Site Characterization for On-Site Septic Systems (D 5879-95), ASTM Practice for Subsurface Site Characterization of Test Pits for On-Site Septic Systems (D 5921-96), and ASTM Practice for Preliminary Sizing and Delineation of Soil Absorption Field Areas for On-Site Septic Systems (D 5925-96).

## D 5879-95
## Practice for Surface Site Characterization for On-Site Septic Systems

*1. Scope*

1.1 This practice covers procedures for the characterization of surface conditions at a site for evaluating suitability for an on-site septic system for disposal and treatment of wastewater. This practice provides a method for identifying potentially suitable areas for soil absorption of septic tank wastewater.

1.2 This practice can be used at any site where on-site treatment of residential and non-hazardous commercial wastewaters using septic tanks and natural soils or constructed filter beds is required or an option under consideration. This practice may also be useful when constructed wetlands are used as an alternative wastewater treatment method.

1.3 This practice should be used in conjunction with Practices D 5921 and D 5925.

## D 5921-96
## Practice for Subsurface Site Characterization of Test Pits for On-Site Septic Systems

*1. Scope*

1.1 This practice covers procedures for the characterization of subsurface soil conditions at a site as part of the process for evaluating suitability for an on-site septic system. This practice provides a method for determining the usable unsaturated soil depth for septic tank effluent to infiltrate for treatment and disposal.

1.2 This practice describes a procedure for classifying soil by field observable characteristics within the United States Department of Agriculture, Soil Conservation Service (SCS) classification system.[2] The SCS classification system is defined in Refs **(1–4)**,[3] not in this practice. This practice is based on visual examination and manual tests that can be performed in the field. This practice is intended to provide information about soil characteristics in terms that are in common use by soil scientists, public health sanitarians, geologists, and engineers currently involved in the evaluation of soil conditions for septic systems.

1.3 This procedure can be augmented by Test Method D 422, when verification or comparison of field techniques is required. Other standard test methods that may be used to augment this practice include: Test Methods D 2325, D 3152, D 5093, D 3385, and D 2434.

1.4 This practice is not intended to replace Practice D 2488 which can be used in conjunction with this practice if construction engineering interpretations of soil properties are required.

1.5 This practice should be used in conjunction with D 5879 to determine a recommended field area for an on-site septic system. Where applicable regulations define loading rates-based soil characteristics, this practice, in conjunction with D 5925, can be used to determine septic tank effluent application rates to the soil.

1.6 This practice should be used to complement standard practices developed at state and local levels to characterize soil for on-site septic systems.

1.7 The values stated in SI units are to be regarded as the standard.

1.8 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

**D 5925-96**
**Practice for Preliminary Sizing and Delineation of Soil Absorption Field Areas for On-Site Septic Systems**

*1. Scope*

1.1 This practice covers procedures for estimating the dimensions and marking the boundaries of a soil absorption area for an on-site septic system involving residential-strength wastewater. It can also be used to estimate the dimensions of commercial on-site septic systems where wastewater strengths are similar to residential wastewater.

1.2 This practice can also be used for marking the boundaries of the area for a septic system constructed filter bed.

1.3 This practice can be used at any site where a potentially suitable or recommended field area has been identified in accordance with Practices D 5879 and D 5921.

1.4 Non-metric units remain the common practice in design and installation of on-site waste disposal systems, and are used in this practice. Use of SI units given in parentheses is encouraged, if acceptable to the appropriate permitting agency.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

# APPENDIX B

## Terminology

The following terms have been defined for use as specifically related to on-site septic systems in ASTM standards D 5879, D 5921, and D 5925.

*clinometer*—an instrument for measuring inclination, as in topographic slope.

*constructed filter bed*—a material, usually of a sandy texture, placed above or in an excavated portion of the natural soil for filtration and purification of wastewater from an on-site septic system.

*limiting depth*—for the purpose of determining suitability for on-site septic systems, the depth at which the flow of water, air, or the downward growth of plant roots is restricted.
*mottle*—spots or blotches of different colors or shades of color interspersed with the dominant color (**5**). In SCS (**3**) practice mottles associated with wetness in the soil are called redox concentrations or redox depletions.
*on-site septic system*—any wastewater treatment and disposal system that uses a septic tank or functionally equivalent device for collecting waste solids and treats wastewater using natural soils, or constructed filter beds with disposal of the treated wastewater into the natural soil.
*pocket penetrometer*—a hand operated calibrated spring instrument used to measure resistance of the soil to compressive force.
*potentially suitable field area*—the portions of a site that remain after observing limiting surface features such as excessive slope, unsuitable landscape position, proximity to water supplies, and applicable setbacks have been excluded.
*recommended field area*—the portion of the potentially suitable field area at a site that has been determined to be most suitable as a septic tank soil absorption field or filter bed based on surface and subsurface observations.
*soil absorption area*—an area of natural soil used for filtration and purification of wastewater from an on-site septic system.
*soil absorption field area*—an area that includes soil absorption trenches and any soil barriers between the trenches. Also called a *leachfield.*
*soil absorption trench*—an excavated trench, usually 1.5 to 3 ft wide that receives wastewater for treatment. Also called a *lateral* or *leachline.*
*unsaturated*—soil water condition at which the void spaces that are able to be filled are less than full.
*vertical separation*—the depth of unsaturated, native, undisturbed soil between and bottom of the disposal component of the septic system and the limiting depth.

# APPENDIX C

### ASTM Standards Related to On-Site Septic Systems

Many ASTM standards have application to site and soils characterization and evaluation with respect to design of on-site septic systems. In addition, many ASTM standards are related to on-site system components and materials used in construction and the procedures related to the use of these components and materials. A list of ASTM standards with titles are given below.

### Standards Related to Site and Materials Characterization, Tests and Evaluation

| | |
|---|---|
| D 420-93 | Guide to Site Characterization for Engineering, Design, and Construction Purposes |
| D 5879-95 | Practice for Surface Site Characterization for On-Site Septic Systems |
| D 5921-96 | Practice for Subsurface Site Characterization of Test Pits for On-Site Septic Systems |
| D 5925-96 | Practice for Preliminary Sizing and Delineation of Soil Absorption Field Areas for On-Site Septic Systems |
| D 1452-80 (1995) | Practice for Soil Investigation and Sampling by Auger Borings |
| D 3385-94 | Test Method for Infiltration Rate of Soils in Field Using Double-Ring Infiltrometer |
| D 5093-90 | Test Method for Field Measurement of Infiltration Rate Using a Double-Ring Infiltrometer with a Sealed-Inner Ring |

| | |
|---|---|
| D 2487-93 | Test Methods for Classification of Soils for Engineering Purposes (Unified Soil Classification System) |
| D 2488-93 | Practice for Description and Identification of Soils (Visual-Manual Procedure) |
| D 5434-93 | Guide for Field Logging of Subsurface Explorations of Soil and Rock |
| D 4700-91 | Guide for Soil Sampling from the Vadose Zone |
| D 5126-90 | Guide for Comparison of Field Methods for Determining Hydraulic Conductivity in the Vadose Zone |
| D 5911-96 | Practice for Minimum Set of Data Elements to Identify a Soil Sampling |
| D 5092-90 (1995) | Practices for Design and Installation of Ground Water Monitoring Wells in Aquifers |

### Standards Related to On-Site Systems Components, Materials, and Construction Procedures

| | |
|---|---|
| C 33-93 | Specification for Concrete Aggregates |
| C 913-96 | Specification for Precast Concrete Water and Wastewater Structures |
| C 1227-96 | Specification for Precast Concrete Septic Tanks |
| D 1785-96a$^{\epsilon 1}$ | Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120 |
| D 2241-96a | Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series) |
| D 2729-96 | Specification for Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings |
| D 5101-96 | Test Method for Measuring the Soil-Geotextile System Clogging Potential (By the Gradient Ratio) |
| E 1609-94 | Guide for Development and Implementation of a Pollution Prevention Program |
| D 2321-89 (1995) | Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications |
| D 2564-96a | Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Pipe and Fittings |
| D 2855-96 | Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings |
| D 3083-89 | Specification for Flexible Poly(Vinyl Chloride) Plastic Sheeting for Pond, Canal, and Reservoir Lining |
| D 4551-96 | Specification for Poly(Vinyl Chloride) (PVC) Plastic Flexible Concealed Water-Containment Membrane |
| D 449-89 (1994)$^{\epsilon 1}$ | Specification for Asphalt Used in Dampproofing and Waterproofing |
| D 645-92 | Test method for Thickness of Paper and Paperboard |
| D 1668-95 | Specification for Glass Fabrics (Woven and Treated) for Roofing and Waterproofing |

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