



Chapter 2

Selection, Design and Implementation of Decentralized Infrastructure

2-1. Scope

Decentralized infrastructure involves approaches, technologies and systems that are selected based on project goals and requirements under a specific set of circumstances. For a particular project, one or more decentralized systems can be configured from compatible approaches and technologies. System design and implementation needs to satisfy technical and deployment viability and sustainability requirements. Management is essential to successful deployment of decentralized systems. This chapter describes how decentralized systems can be selected, designed, and implemented to achieve project goals and satisfy requirements in a sustainable fashion.

2-2. Key Concepts

- Infrastructure can be defined as the basic physical and organizational structures and facilities needed for a given function within a society. In the context of wastewater management and water reclamation, decentralized infrastructure can encompass an array of approaches, technologies, and systems.
 - For example, decentralized infrastructure can span from:
 - Installation of ultra-efficient fixtures and appliances (e.g., water-less or urine diverting toilets) in buildings to reduce water use and wastewater generation, to
 - Installation of a complete treatment system (e.g., membrane bio-reactor and ultraviolet light disinfection unit) to enable nonpotable water reuse for toilet flushing and irrigation.

- Decentralized infrastructure can be deployed to help achieve one or more project goals that commonly include:
 - Effective treatment and disposal of wastewaters in areas where a decentralized system is the only option or where decentralized systems offer desired benefits.
 - Treatment of wastewaters to provide a reclaimed water source in areas where decentralized approaches can yield benefits by co-locating wastewater generation near a water reuse site.
 - Minimize resource consumption and maximize resource recovery in areas where these are desired by the project owners for various reasons such as to support an environmental consciousness, realize cost incentives or savings, and earn points to achieve a desired green building rating.
- A variety of general considerations can influence if and how decentralized infrastructure might be deployed for a particular project including:
 - What are the key characteristics of the source(s) or development to be served by the approach, technology or system?
 - What are the optional receiving environments and boundary conditions that determine what water quality is required for a potential discharge or reuse option?
 - Is the project to provide upgraded or new service?
 - Are there any existing or planned systems near the existing or planned building or development?
 - What is the design life of the approach, technology or system?
 - How will the approach, technology or system be paid for and managed?
 - What regulatory program(s) governs design and implementation of an approach, technology or system?
- Selection, design and implementation of decentralized infrastructure must ensure viability and sustainability.
 - Approaches, technologies, and systems that are considered “technically viable” for a particular application are those that are inherently capable of achieving a required goal (e.g., a required treatment efficiency for an intended discharge or reuse plan and capable of satisfying high priority owner requirements).
 - Approaches, technologies, and systems that are considered “deployment viable” are those that are also compliant with applicable regulations and codes.
 - Approaches, technologies, and systems that are considered “sustainable” must provide a reliable performance in an affordable manner over the long-term and also yield an acceptable level of resource use and environmental impact.

- For most projects, decentralized infrastructure includes one or more systems for wastewater treatment and water reclamation, potentially including resource recovery.
 - Chapter 2 is focused on the selection, design and implementation of viable and sustainable decentralized systems for wastewater treatment and water reclamation.
 - As described in this chapter, a viable and sustainable decentralized system can be configured from one or more approaches and technologies and can include minimum flow fixtures and appliances, waste stream source separation and treatment technologies and reuse and recovery options.
- Project requirements drive system selection, design and implementation and these can be categorized to include:
 - Requirements based on treatment efficiency and water quality—Treatment performance must protect public health and preserve or enhance environmental quality and also provide for an operation that is robust and reliable.
 - Requirements based on owner needs and desires—Owner(s) can have specific views about what infrastructure they want to implement, including: attributes related to aesthetics and land use planning, costs relative to an available budget, sustainability attributes, and contribution to achieving a certain green building or infrastructure rating.
 - Requirements based on regulations and codes—Codes and regulations can constrain what can be permitted and also specify how design and implementation is done.
- Project requirements can include specified treatment efficiency targets for constituents of concern (e.g., achieve $\geq 50\%$ removal of total inorganic nitrogen with an effluent concentration < 10 mg-N/L). A system must have the inherent capability to achieve a target treatment efficiency, be properly designed and implemented for a particular project, be properly operated and maintained, and if needed be appropriately monitored to verify performance is achieved.
- Constituents of concern can be removed using approaches such as source separation and treatment processes such as biodegradation that are implemented in unit operations. Compatible approaches and unit operations can be selected to form a system that has a general capability to remove the constituents of concern. Systems commonly include a treatment train that consists of a sequence of compatible unit operations that connect the source to an intended discharge or reuse option. The unit operations in a treatment train can be categorized

according to their function and the constituents of concern that are removed:

- Preliminary treatment—A term used to encompass processes and unit operations that are used to accomplish the initial processing of raw wastewaters generated in buildings, which often includes the removal of debris and fats, oils, and greases. Examples of preliminary treatment include grease interceptors, coarse screening units, grinders and comminutors.
 - Primary treatment—A term used to encompass processes and unit operations that remove suspended solids (organic and inorganic) from wastewater by sedimentation or flotation processes. Advanced primary treatment includes some treatment of the separated solids (e.g., by anaerobic biodegradation of settled organic solids). Examples of primary treatment operations include settling basins, septic tanks, and upflow anaerobic sludge blanket reactors.
 - Secondary treatment—A term used to encompass processes and unit operations that follow primary treatment and are designed to remove biodegradable dissolved and colloidal organic matter by aerobic biological processes. Advanced secondary treatment includes transformation and removal of nutrients (e.g., removal of ammonia nitrogen using a nitrifying extended aeration bioreactor). Examples of secondary treatment operations include: extended aeration bioreactors, porous media biofilters, and constructed wetlands.
 - Tertiary treatment—A term used to encompass processes and unit operations that typically follow secondary treatment and are designed to remove specific constituents such as nutrients, trace organic compounds, heavy metals or dissolved salts. Examples of tertiary treatment operations include: denitrifying porous media biofilters, adsorptive media packed bed reactors, and ion exchange columns.
 - Disinfection—Refers to the process of destroying pathogenic microorganisms in a media like water so that the risk of infectious disease transmission through human contact with that media is reduced. Examples of disinfection technologies include: chlorination, ozonation, ultraviolet light irradiation, and membrane filtration.
- Unit operations and systems can have inherent treatment capabilities, which are established based on field experiences and testing and evaluation programs. The National Sanitation Foundation has had a program of testing and certification in place for more than 40 years. Today there are a number of standards that can be used to test and certify different types of fixtures and treatment systems relative to a set of criteria that must be met. Examples of current standards include: Standard 40 for residential treatment systems, Standard 245 for nitrogen reduction systems, and Standard 350 and 350-1 for water reuse treatment systems.

- The treatment that is actually realized when a technology or system is applied at a specific project can be better or worse than an inherent capability and the performance demonstrated in testing and evaluation programs. The fundamental reason for this is that specific projects can have design and implementation that can vary in the quality of execution and the conditions actually encountered during operation can depart from those envisioned during design and implementation.
 - Design reviews and approvals, construction supervision and inspections, education and training, and certification programs for those involved in key elements can help enable proper design and implementation.
 - Operation and maintenance can be critical to achieving an inherent system treatment capability over a system design life. Operation and maintenance requirements vary in complexity and frequency of occurrence. The operation and maintenance required to ensure that an inherent treatment capability is actually realized increases with system complexity and the stringency of the treatment efficiency targets.
 - The importance of monitoring depends on the risks associated with system performance deficiencies. Monitoring methods can be used to determine the operational status or treatment performance of a unit operation or system. Monitoring data can be used to assess and alter operations to help ensure achievement of the target treatment efficiency.
- System configurations can help satisfy environmental sustainability goals. These goals can include minimizing resource use directly or via recovery along with minimizing environmental impacts associated with resource use and conveyance and treatment operations.
 - Sustainability assessment can be used during strategic planning of infrastructure in areas or regions. Life Cycle Assessment has been used to assess decentralized versus centralized infrastructure options in several urban planning areas.
- Management is crucial to ensure the viability and sustainability of decentralized systems.
 - Modern management systems involve entities and activities, often organized within a jurisdiction, to ensure decentralized systems are properly considered during infrastructure and land use planning, and if selected they are properly designed, constructed, and operated so performance is satisfactory over a long-term planning period.

2-3. Conceptual and Technical Details

Conceptual and technical details concerning the scope and key concepts covered in Chap. 2 are presented in the Slides section.

2-4. Terminology

Terminology introduced and used in Chap. 2 is defined below.

Blackwater—Wastewaters from water-flush toilets and potentially including wastewaters from kitchen sink and dishwasher uses.

Configuring decentralized systems—The engineering process of selecting and combining compatible strategies and unit operations to form a system that is considered viable and sustainable for a particular project application.

Deployment viable systems—Decentralized systems that are technically viable for a particular application and are also compliant with applicable regulations and codes.

Disinfection—Refers to the process of destroying pathogenic microorganisms in a media like water so that the risk of infectious disease transmission through human contact with that media is reduced. Example processes include chlorination, ultraviolet light irradiation, and membrane filtration. See also Natural disinfection.

E. coli—*Escherichia coli* is a bacterium found in the gut that is used as an indicator of fecal contamination of water.

Graywater—Wastewaters produced by water use in basins, sinks and appliances in residential and nonresidential buildings. Mixed graywater includes food preparation related wastewaters (e.g., kitchen sink and dishwasher) while light graywater excludes food preparation wastewaters and possibly laundry wastewaters. All types of graywater exclude toilet wastewaters, which contain human excreta. Graywater can also be spelled as greywater.

Infrastructure—The basic physical and organizational structures and facilities needed for a given function such as water treatment and supply or wastewater treatment and discharge or water reuse.

Impaired water—Refers to water that has been used or impacted in a manner as to have quality characteristics that make it unsuited for one or more uses. Examples of impaired waters include: residential and commercial wastewater, municipal wastewater, graywater, stormwater, acid mine drainage, etc.

Management systems—Management systems involve entities and activities, often organized within a jurisdiction, to ensure decentralized systems are properly considered during infrastructure and land use planning, and if

selected they are properly designed, constructed, and operated so performance is satisfactory over a long-term planning period.

Maximum Contaminant Level (MCL)—The highest level of a contaminant that is allowed in drinking water in the United States under the Safe Drinking Water Act.

Natural disinfection—Refers to the destruction of pathogenic microorganisms by die-off and predation mechanisms in unit operations that are not specifically designed as disinfection agent technologies. See also Disinfection.

Performance-based design—An explicit approach to achieving performance that allows designers to develop solutions to achieve a numerical performance requirement (e.g., 10 mg-N/L) that can provide for flexibility and innovation in design, but can require monitoring to verify performance.

Prescriptive design—An implicit approach to achieving performance where regulatory requirements dictate the steps and methods to be adhered to in system planning, design, and operation and satisfactory performance is presumed to be achieved if the prescribed code requirements are met.

Preliminary treatment—A term used to encompass processes and unit operations that are used to accomplish the initial processing of raw wastewaters generated in buildings, which often includes the removal of debris and fats, oils, and greases. Examples of preliminary treatment include: grease interceptors, coarse screening units, grinders and comminutors.

Primary treatment—A term used to encompass processes and unit operations that remove suspended solids (organic and inorganic) from wastewater by sedimentation or flotation processes. Advanced primary treatment includes some treatment of the separated solids (e.g., by anaerobic biodegradation of settled organic solids). Examples of primary treatment operations include settling basins, septic tanks, and upflow anaerobic sludge blanket reactors.

Reclaimed water—Reclaimed water is wastewater that has been treated to remove inorganic and organic substances and pathogenic microorganisms to a degree that the effluent can be considered reclaimed water with a quality that is fit for the purpose (i.e., appropriate for and of a necessary standard) of an intended discharge or water reuse plan.

SCADA—An acronym for supervisory control and data acquisition systems that are used to gather and analyze real-time data to monitor and control a unit operation or system.

Secondary treatment—A term used to encompass processes and unit operations that follow primary treatment and are designed to remove biodegradable dissolved and colloidal organic matter by aerobic biological processes. Examples of secondary treatment operations include extended aeration bioreactors, porous media biofilters, and constructed wetlands.

Sustainable systems—In the context of decentralized wastewater treatment and water reclamation, sustainable systems are systems that are

selected, designed, and implemented for a particular application that are capable of achieving long-term, reliable performance, have affordable costs for construction and operation, and have acceptably low resource requirements and environmental impacts.

Technically viable systems—Decentralized systems for a particular application that are capable of achieving a required treatment efficiency for an intended discharge or reuse plan and are also capable of satisfying high priority owner requirements.

Tertiary treatment (Advanced treatment)—A term used to encompass processes and unit operations that typically follow secondary treatment and are designed to remove specific constituents such as nutrients, trace organic compounds, heavy metals or dissolved salts. Examples of tertiary treatment operations include: denitrifying porous media biofilters, adsorptive media packed bed reactors, and ion exchange columns.

Treatment technique—A required process (in the United States) intended to reduce the level of a contaminant in drinking water.

Treatment train—Within a decentralized system a treatment train consists of a sequence of compatible unit operations that connect the source to an intended discharge or reuse option.

Unit operation—A physical facility (e.g., basin, column, reactor, landscape) in which a physical, chemical, and/or biological process is made to occur for the purpose of removing or destroying constituents of potential concern in wastewater or other impaired waters.

Yellow water—Term that can be used to represent human urine.

2-5. Acronyms, Abbreviations and Symbols

Acronyms, abbreviations and symbols used in Chap. 2 are listed below.

BOD	Biochemical oxygen demand
BREEAM	Building research establishment environmental assessment method
cBOD	Carbonaceous BOD
CDPHE	Colorado Department of Public Health and Environment
Coli.	Coliform bacteria
CSM	Colorado School of Mines
<i>E. coli</i>	<i>Escherichia coli</i>
LCA	Life-cycle assessment
LEED	Leadership in energy and environmental design
MASSTC	Massachusetts Alternative Septic System Test Center
MBR	Membrane bioreactor
N	Nitrogen
ND	None detected

NPV	Net present value
NS	Not specified
NSF	National Sanitation Foundation (U.S.), National Science Foundation (U.S.)
NTU	Normal turbidity units
O&M	Operation and maintenance
O&P	Operational and performance
RME	Responsible management entity
SCADA	Supervisory control and data acquisition
TIN	Total inorganic nitrogen
TMDLs	Total maximum daily loads to a water body
TSS	Total suspended solids
U.S.	United States of America
USEPA	U.S. Environmental Protection Agency
UV	Ultraviolet light

2-6. Problems

- 2.1 A university is considering expansion of student housing on the campus and is interested in exploring decentralized infrastructure and options for water reclamation and reuse. As a design professional, you were invited to a meeting with a campus planning team to discuss this. List five relevant questions you might ask during the meeting or pursue after the meeting to help begin to understand whether there would be viable options for implementing a decentralized approach, technology or system.
- 2.2 Environmental regulations that are relevant for decentralized infrastructure are often conservative and can limit application of innovative technology. Briefly explain why this is the case.
- 2.3 There are perhaps eight different basic considerations that could be important during initial planning of a suburban housing development with a design flow of 10,000 gal/day that is located near the edge of a city that is already served by conventional centralized wastewater facilities. These considerations could strongly influence whether a decentralized system might be most appropriate compared to a extending a sewer to connect the development to the city's centralized treatment plant. Which of the following would likely apply: (1) distance from the subdivision development to the city and a sewer connection point, (2) development size and density, (3) architectural style of the houses, (4) topography and natural resources where the development is located, (5) amount of excess capacity in the city's wastewater

- facilities, (6) developer's desire or need to maintain control over beneficial reuse?
- 2.4 Treatment performance requirements can be achieved by prescriptive vs. performance-based design. Briefly explain the difference in prescriptive vs. performance-based design.
 - 2.5 Decentralized systems can combine available unit operations in an optimum fashion to achieve required performance efficiencies, satisfy owner and user requirements, and comply with regulatory requirements. For a resort development of 100 condominiums, what might be the reason why a high priority owner requirement is to minimize resource requirements and enable recovery.
 - 2.6 Which of the following are factors to consider when assessing technical viability (check all that apply): (1) previous experience with a particular type of application, (2) treatment requirements and process reliability, (3) compatibility with other unit operations or systems, (4) power, chemical, and other resource requirements, (5) type and management of treatment residuals?
 - 2.7 For a new subdivision development in Arizona, you are tasked with configuring a decentralized system for each of the following two goals: (1) to effectively treat the wastewater generated for discharge of effluent into a nearby creek or (2) to produce reclaimed water for landscape irrigation in the subdivision. Assemble a technically viable decentralized system you would propose. Give a brief explanation concerning the basis for your selection and state any assumptions you need or choose to make.
 - 2.8 There are several technical, environmental, and economic benefits that can be gained by water recycling and reuse. There are also a few concerns. Describe one important benefit and one important concern.
 - 2.9 Rating systems for green buildings can motivate selection and use of decentralized water reclamation approaches, technologies, and systems. Give two examples of an approach or technology for which a rating system such as LEED can allocate points in the general category of water efficiency.
 - 2.10 Regulations and guidelines can control water recycling and reuse practices. Fill in the blanks to complete the following phrases that represent common features of water recycling and reuse regulations and guidelines: (1) primary emphasis is on _____ protection, (2) requirements include _____ processes plus _____ limits for different recycling and reuse options, (3) _____ is almost universally required.
 - 2.11 Answer the following questions concerning water recycling and reuse. (1) Compared to total domestic wastewater, household graywater should present a lower risk to human health and thus be more amenable to recycling and reuse—true or false? (2) Check which one of the following levels of treatment best describes the generally accepted practice to produce water for landscape irrigation or toilet flushing:

- secondary, secondary with disinfection, secondary plus filtration and disinfection. (3) For unrestricted urban reuse, regulations often require treatment that produces a reclaimed water with very low turbidity (e.g., ≤ 2 NTU) to improve disinfection reliability—true or false?
- 2.12 The primary risk factor controlling the level of treatment technically required to produce reclaimed water for landscape irrigation is the degree of _____.
- 2.13 For each of the following four situations (a–d) state which of the following management models might be most appropriate: (1) user awareness, (2) maintenance contract, (3) RME operation, (4) RME own and operate. Use all choices (1–4) but use each one only once. Situations: (a) A decentralized system managed by a sanitation district that includes individual septic tanks at 100 homes located along a lake shore with an alternative collection system and treatment using sub-surface soil infiltration at a site located on an upslope area about 2 miles away from the lake. (b) Subsurface soil infiltration serving individual homes located on 5-acre lots in a rural county of eastern Colorado. (c) A decentralized system serving a private resort development in California with 20, 4-unit condominium buildings where water reuse for landscape irrigation is planned following treatment in a centrally located treatment facility including a membrane bioreactor and UV disinfection. (d) A county in Illinois with shallow groundwater where there is an increasing use of recirculating sand filters to produce a high quality effluent for landscape drip dispersal.

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¹References cited in Chap. 2 are listed along with other references that have content relevant to the topics covered in Chap. 2.

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Slides of Chapter 2

Decentralized Water Reclamation

Chapter 2: Selection, Design, and Implementation of Decentralized Infrastructure

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2.1



2-1. Introduction

- Decentralized infrastructure can be defined as the basic physical and organizational structures and facilities needed for a given function within a society
 - In the context of wastewater management and water reclamation, decentralized infrastructure can be considered to encompass an array of approaches, technologies, and systems
 - For example, it can range from:
 - Installation of ultra-efficient fixtures and appliances (e.g., waterless or urine diverting toilets) ... to ...
 - Installation of a complete treatment and reuse system (e.g., membrane bioreactor and ultraviolet light disinfection unit for nonpotable water reuse for toilet flushing and irrigation)
 - For most projects, decentralized infrastructure includes one or more systems for wastewater treatment and water reclamation, potentially including resource recovery

2.2



- Decentralized infrastructure can be deployed to help achieve one or more project goals that commonly include:
 - Effective treatment and disposal of wastewaters in areas where a decentralized system is the only option or where decentralized systems offer desired benefits
 - Treatment of wastewaters to provide a reclaimed water source in areas where decentralized approaches can yield benefits by co-locating wastewater generation near a water reuse site
 - Minimize resource consumption and maximize resource recovery in areas where these are desired by the project owners (e.g., to realize cost incentives or savings and/or earn points to achieve a desired green building rating)
- Varied considerations can influence if, and how, decentralized infrastructure is deployed (Table 2.1)

2.3



Table 2.1 Considerations influencing if and how decentralized infrastructure may help achieve goals

Consideration	Comments
What are the key characteristics of the source(s) or development to be served?	Type of source, number of users, size of source, individual building or a development of a certain density, availability and cost of utility services, geographic location, climatic conditions
What are the optional receiving environments and what water quality is needed?	Receiving environments (typically land or water) can include reuse elements (e.g., irrigation, habitat enhancement). Recycling and reuse have different water quality requirements
Is the project to provide upgraded or new service?	Upgrading an existing building, development, facility can be much more complicated than implementing a new service
Are there existing or planned infrastructure systems near the project?	Connection to an existing or planned system might be a viable option
What is the design life of the infrastructure?	Design life, including operation and maintenance requirements, can influence viable options
How will the infrastructure be paid for and managed?	Private, corporate, vs. public ownership and management can dictate what infrastructure is feasible and affordable
Regulatory program(s) requirements?	Regulations often constrain and control what can be done

2.4



- Infrastructure selection, design, and implementation
 - Decentralized infrastructure needs to be selected, designed, and implemented to ensure viability and sustainability
 - Approaches, technologies, and systems that are considered “technically viable” for a particular application are those that are:
 - Capable of achieving a required treatment efficiency for an intended discharge or reuse plan
 - Capable of satisfying high priority owner requirements
 - Approaches, technologies, and systems that are considered “deployment viable” are those that are also compliant with applicable regulations and codes
 - Approaches, technologies, and systems that are considered “sustainable” must provide a reliable performance in an affordable manner over the long-term and also yield an acceptable level of resource use and environmental impact

2.5



- Depending on the project goals and requirements, decentralized infrastructure can take many forms
 - Decentralized approaches can be used within a centralized infrastructure setting, e.g.:
 - Installation of ultra-efficient fixtures and appliances in buildings to minimize water use and wastewater generation
 - Decentralized systems can be configured from technologies that are applicable to decentralized infrastructure settings, e.g.:
 - Compatible unit operations can be combined into one or more systems to provide wastewater treatment and water reclamation
- Focus of Chap. 2
 - Chapter 2 is focused on the selection, design, and implementation of viable and sustainable decentralized systems for wastewater treatment and water reclamation including systems which can enable resource recovery

2.6



2-2. Project Requirements


- Project requirements can be categorized to include:
 - Requirements based on treatment efficiency and water quality
 - System performance must yield a water quality suited to an intended discharge or reuse function
 - Requirements based on owner needs and desires
 - Owner(s) can have specific views about what system they want to implement, including:
 - * Attributes related to aesthetics and land use planning
 - * Costs relative to an available budget
 - * Sustainability attributes
 - * Contribution to achieving a green building rating
 - Requirements based on regulations and codes
 - System design and implementation must satisfy applicable code requirements
 - Codes can specify how design and implementation can occur

2.7



- Requirements based on treatment efficiency
 - Are designed to:
 - Protect public health and environmental quality
 - Can be based on:
 - Generic public health or environmental criteria or standards
 - Site-specific criteria and goals (e.g., by risk assessment)
 - Can be impacted by:
 - Other sources of pollutants within a given service area, e.g., area or watershed scale considerations (e.g., Total Maximum Daily Loads (TMDLs) in a watershed)
 - Can be stipulated by:
 - Regulations and codes

2.8



■ Examples of criteria and standards for water quality that can impact treatment requirements are shown in Tables 2.2 and 2.3

Table 2.2 Example drinking water standards and criteria that could be used to set treatment efficiency requirements for a decentralized system discharging into the subsurface for groundwater recharge

Contaminant	MCL ^a	TT ^b	Reason	
Nitrate (mg-N/L)	10	10	Infants below the age of 6 months who drink water containing nitrate in excess of the MCL could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue-baby syndrome	
Viruses (enteric)	Zero	TT	Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	
Contaminant		pH	Total dissolved solids	Iron
Secondary guidelines ^c		6.5–8.5	500 mg/L	0.3 mg/L

Source: <http://water.epa.gov/drink/contaminants/index.cfm#List>.
^aMaximum Contaminant Level (MCL)—The highest level of a contaminant that is allowed in drinking water.
^bTreatment Technique—A required process intended to reduce the level of a contaminant in drinking water.
^cNon-enforceable guidelines regulating contaminants that may cause cosmetic or aesthetic effects.

2.9




Table 2.3 Examples of state requirements for unrestricted urban water reuse that could be applied to effluent used for landscape irrigation (USEPA 2004)

Example state requirements for “unrestricted urban reuse”							
Req’t.	Arizona	California	Florida	Hawaii	Nevada	Texas	Washington
Treatment	Secondary, filtered, disinfected	Oxidized, coagulated, filtered, disinfected	Secondary, filtered, high-level disinfected	Oxidized, filtered, disinfected	Secondary, disinfected	NS ^a	Oxidized, coagulated, filtered, disinfected
BOD ₅ (mg/L)	NS	NS	20 cBOD ₅	NS	30	5	30
TSS (mg/L)	NS	NS	5	NS	NS	NS	30
Turbidity (NTU)	Avg. = 2 Max = 5	Avg. = 2 Max = 5	NS	Max = 2	NS	3	Avg. = 2 Max = 5
Total coli. (°/100 mL)	NS	Avg. = 2.2 Max. = 23	NS	NS	NS	NS	Avg. = 2.2 Max. = 23
Fecal coli. (°/100 mL)	Avg. = 0 Max. = 23	NS	75 % ND ^b Max. = 25	Avg. = 2.2 Max. = 23	Avg. = 2.2 Max. = 23	Avg. = 20 Max. = 75	NS

Note: For updated requirements and guidelines see USEPA 2012 Guidelines for Water Reuse.
^aNS not specified in state regulations.
^bNone detected.

2.10



- Treatment efficiency requirements for a project can often lead to specifications
 - Example specifications for a system involving treated effluent dispersal into subsurface soil and local recharge of groundwater is presented in Table 2.4

Table 2.4 Example specifications for a decentralized system that disperses treated effluent into the subsurface with recharge of local groundwater

Specification parameter	Specification value
Critical parameters of concern	Nitrate nitrogen
Maximum allowable concentration	10 mg-N/L
Media and point at which requirements apply	Groundwater at the property boundary
Frequency and intensity of observation	Quarterly monitoring of three down gradient groundwater wells
Method of comparing data to requirements	Annual average < allowable concentration

2.11



- Treatment efficiency requirements can be met via prescriptive- or performance-based design
 - Prescriptive design—common; can be an implicit approach to achieving performance
 - Regulatory requirements *dictate* the steps and methods to be adhered to in system planning, design, and operation
 - Satisfactory performance is *presumed* to be achieved if the prescribed code requirements are met
 - Performance-based design—less common; is an explicit approach to achieving performance
 - Allows designers to develop solutions to achieve a numerical performance requirement (e.g., 10 mg-N/L)
 - Can provide for flexibility and innovation in design, but can require monitoring to verify performance

2.12



- Owner requirements also need to be met, including:
 - Requirements regarding system type and land use planning
 - Requirements based on affordability and cash flow
 - Requirements based on sustainability attributes
- Owner requirements regarding system type and land use
 - Owners can have specific desires related to the type of system and land use planning
 - Preferences for one system type over another
 - * e.g., landscape-based system versus a reactor-based system (e.g., preference for a constructed wetland over an aerobic unit)
 - Preferences based on type and density of development
 - * e.g., preference for larger individual lots vs. smaller lots with more open space in a clustered development

2.13



- Owner requirements based on affordability and cash flow
 - Owners can have a certain budget and financing arrangement that they have to work within
 - As a result, financial costs need to be estimated
 - Costs include projected capital costs plus operation and maintenance (O&M) costs
 - Capital costs = one-time costs to build the infrastructure
 - O&M costs = recurring annual costs
 - The estimated life cycle costs are computed from the amortized capital costs combined with annual O&M costs
 - Based on cash flow considerations, owners can have a preference for systems with low capital costs and higher O&M costs or vice versa

2.14



- Owner requirements based on sustainability attributes
 - Preferences for a system that is environmentally friendly—for example, owners may prefer a more passive natural system versus a more active energy consuming mechanical plant
 - Preferences for a system that helps achieve a certain sustainability rating
 - Green building rating systems, e.g.:
 - * Building Research Establishment Environmental Assessment Method (BREEAM) Rating System (www.breeam.org)
 - * Leadership in Energy & Environmental Design (LEED) (www.usgbc.org/certification)
 - Other rating systems include a focus beyond a single building to include varied infrastructure components, e.g.:
 - * Envision® Sustainable Infrastructure Rating System (www.sustainableinfrastructure.org/rating/)

2.15



- In terms of water management, BREEAM, LEED, and other building rating systems are similar
 - Rating systems have many common elements:
 - * Management of the construction process and sedimentation
 - * Stormwater management for quantity control
 - * Stormwater management for quality/pollution control
 - * Landscape/irrigation water use reduction
 - * Wastewater treatment, either onsite or by reducing offsite flow
 - * Internal fixture water use reduction
 - * Commissioning
 - * Metering of water systems
 - The total points available for all credit categories related to water management range from about 12 to 18 %

2.16



- Requirements based on regulations and codes
 - Regulations and codes can impose varied requirements on system design and implementation
 - Regulations and codes include, but may not be limited to:
 - Building codes (plumbing, electrical, . . .)
 - Drinking water supply regulations
 - Wastewater treatment and discharge regulations
 - Reclaimed water use regulations
 - Stormwater regulations
 - Wetland regulations
 - Water rights regulations
 - Jurisdictions involved in administration of regulations and codes:
 - City and county
 - State and regional
 - Federal

2.17



- For U.S. regulations and codes specific to decentralized wastewater systems, system size and location are often important
 - Smaller individual sources are commonly regulated at the local level (typically at the county level)
 - Common size cut-off used to define “small” is 2000–5000 gal/day, but this varies from state to state
 - Common to have a state-wide code that sets minimum standards for small systems that are implemented at the local level
 - Larger individual sources, clusters, and small communities are often regulated at the state level
 - Potential options and design requirements can vary widely from state to state and from county to county within a state

2.18




- It is important to keep in mind that regulations and codes can be very conservative and constraining
 - Approaches and systems that appear technically viable for a particular application may, in fact, not be permitted under a particular regulation or code
 - This is particularly true for infrastructure to serve single-family homes and small businesses in rural areas
 - This also can be true for “nonconventional” options such as:
 - Source modification (e.g., urine diversion and recovery)
 - Innovative technologies (e.g., membrane units)
 - Reuse options (e.g., nonpotable reuse for toilet flushing)

2.19



- Conservatism often reflects current practical attributes of decentralized systems such as:
 - Highly varied and potentially changing wastewater flows and composition
 - Potential limitations on assuring that all needed operation and maintenance will be provided
 - Difficulties and costs to monitor performance of some components
 - * Notably, natural treatment unit operations and systems
 - Difficulties in achieving corrective action if performance deficiencies do occur
- Fortunately, regulations and codes can evolve and become more contemporary and science-based

2.20



2-3. Treatment Performance

- Project requirements often include specified treatment efficiency targets such as:
 - Producing an effluent quality with BOD₅ and TSS < 30 mg/L
 - Achieving ≥50 % reduction in TIN with an effluent <10 mg-N/L
- Combinations of approaches and technologies can be configured into systems that can offer capability to achieve treatment efficiency targets
 - Compatible approaches and technologies can be selected based on their general capability to remove constituents of concern as described in Table 2.5 and illustrated in Fig. 2.1
 - Within a decentralized system, a treatment train consists of a sequence of compatible unit operations that connect the source of the wastewater to an intended discharge or reuse option as illustrated in Fig. 2.2

2.21


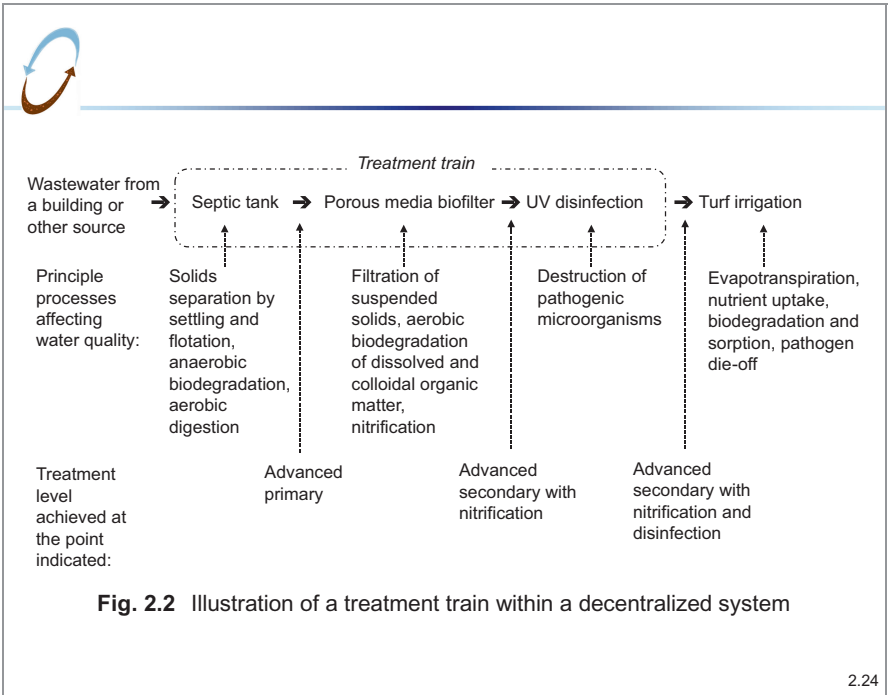
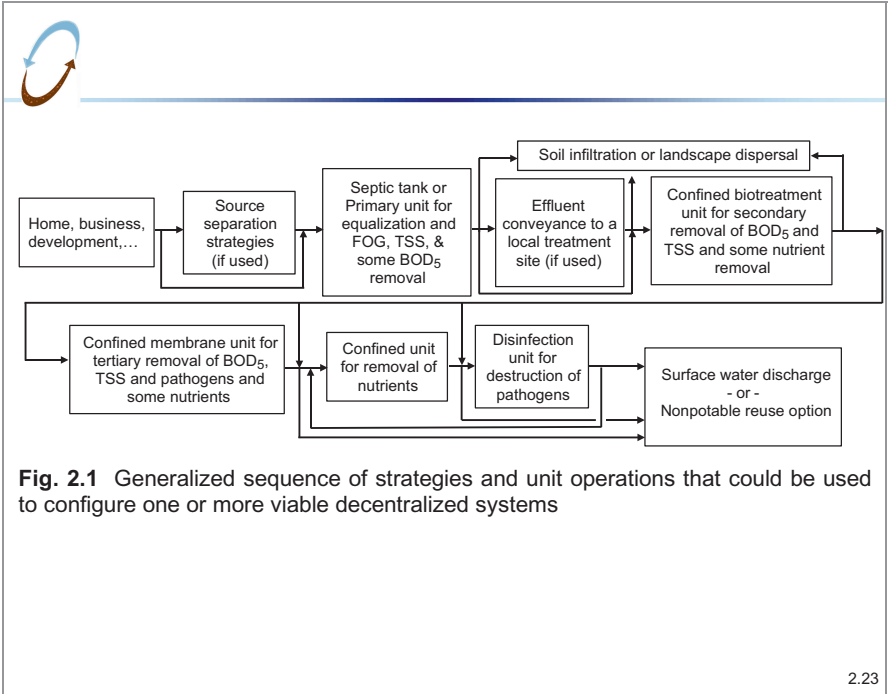


Table 2.5 Treatment levels based on unit operations and the constituents of concern removed

Level ^a	Description
Preliminary treatment	Processes and unit operations that are used to accomplish the initial processing of raw wastewaters generated in buildings, which often includes the removal of debris and fats, oils, and greases. Examples of preliminary treatment include grease interceptors, coarse screening units, and grinders
Primary treatment	Processes and unit operations that remove suspended solids (organic and inorganic) from wastewater by sedimentation or flotation processes. Advanced primary treatment includes some treatment of the separated solids (e.g., by anaerobic biodegradation of settled organic solids). Examples of primary treatment operations include settling basins, septic tanks, and upflow anaerobic sludge blanket reactors
Secondary treatment	Processes and unit operations that follow primary treatment and are designed to remove biodegradable dissolved and colloidal organic matter by aerobic biological processes. Advanced secondary treatment includes transformation and removal of nutrients (e.g., a nitrifying extended aeration bioreactor). Examples of secondary treatment operations include: extended aeration bioreactors, porous media biofilters, and constructed wetlands
Tertiary treatment	Processes and unit operations that typically follow secondary treatment and are designed to remove specific constituents such as nutrients, trace organic compounds, heavy metals or dissolved salts. Examples of tertiary treatment operations include: denitrifying porous media biofilters, adsorptive media packed bed reactors, and ion exchange columns
Disinfection	Processes and unit operations that are designed to destroy pathogenic microorganisms. Examples of disinfection technologies include: chlorination, ozonation, ultraviolet light irradiation, and membrane filtration. Natural disinfection can occur by separation, die-off, predation, and other processes in primary, secondary or tertiary treatment unit operations

^aThe definition of treatment levels can also include specific concentrations of constituents of concern (e.g., secondary treatment achieve 30 mg/L of BOD₅ and TSS) and treatment levels can also be defined in regulations in specific jurisdictions.

2.22





- General and project-specific treatment efficiency capabilities of a particular unit operation or system
 - Different unit operations and systems have general treatment capabilities that a designer can be confident about, for example:
 - Capability of a septic tank to produce primary quality effluent
 - Capability of a recirculating sand filter to produce secondary effluent
 - Capability of a membrane bioreactor to produce tertiary quality effluent
 - The capability to meet specific expectations for a particular project can be less certain, for example:
 - Capability of a particular system to produce an effluent with BOD_5 , TSS, and $\text{TIN} \leq 5 \text{ mg-N/L}$ consistently ($\geq 90\%$ of the time) when applied to the Mountain Pines Resort

2.25



- Establishing general treatment capabilities
 - General capability can be established through several means
 - For commonly used conventional unit operations and systems
 - * Documentation of treatment capability often occurs through full-scale system field experiences and case histories
 - For innovative and alternative unit operations and systems
 - * Documentation of treatment capability can occur through demonstration and testing, e.g.:
 - National Sanitation Foundation (NSF) testing (Table 2.6)
 - Testing centers (e.g., MASSTC at Buzzard's Bay)
 - USEPA Environmental Technology Verification projects
 - Research programs (e.g., CSM Small Flows)
 - State experimental system programs
 - Tabulated values of achievable treatment efficiencies (such as shown in this book) can thus be developed for different technologies and systems

2.26



Table 2.6 Examples of NSF testing and certification standards relevant to decentralized systems

NSF Standard number and description ^a
NSF/ANSI 40 is a standard for residential wastewater treatment systems with rated capacities between 400 and 1500 gal/day NSF can evaluate any kind of treatment system in test facilities in the U.S., Canada and Europe. To achieve certification, systems must produce an acceptable quality of effluent during a 6-month (26-week) test. Class I systems must achieve a 30-day average of 25 mg/L CBOD ₅ and 30 mg/L TSS or less, and pH 6.0-9.0. System service and maintenance are prohibited during the test period
NSF Standard 41 certifies composting toilets and similar treatment systems that do not use a liquid saturated media as a primary means of storing or treating human excreta or human excreta mixed with other organic household materials. The standard requires a minimum of 6 months of performance testing, which includes design loading and stress testing appropriate to the product class: residential, cottage or day-use park. NSF evaluates a minimum of one system in a controlled laboratory setting, and a minimum of three systems in a mature field setting
NSF/ANSI Standard 245 defines total nitrogen reduction requirements to meet the growing demand for nutrient reduction in coastal areas and sensitive environments. NSF/ANSI 245 covers residential wastewater treatment systems with rated capacities between 400 and 1500 gal (1514 and 5678 L) per day We can evaluate any kind of system, regardless of treatment technology, in test facilities in the U.S., Canada and Europe
To achieve certification, treatment systems must produce an acceptable quality of effluent during a 6-month (26-week) test. System service and maintenance are prohibited during the test period
NSF/ANSI Standard 350 and 350-1 establish material, design, construction and performance requirements for onsite residential and commercial water reuse treatment systems. They also set water quality requirements for the reduction of chemical and microbiological contaminants for non-potable water use. Treated wastewater (i.e. treated effluent) can be used for restricted indoor water use, such as toilet and urinal flushing, and outdoor unrestricted water use, such as lawn irrigation

^aThe listing provided here is for illustrative purposes only and is not comprehensive. Comprehensive and current information can be obtained at the NSF website: <http://www.nsf.org/services/by-industry/water-wastewater/onsite-wastewater/>.

2.27



- Treatment efficiency actually achieved vs. general capabilities
 - Treatment efficiency actually achieved for a particular project can be better or worse than expected—why?
 - A system may be improperly designed and implemented
 - * Incorrect estimates of design flows and pollutant loadings
 - * Inaccurate design computations
 - * Poor siting and construction
 - * Inadequate startup and early operation
 - A system can be properly designed and implemented, but. . .
 - * Conditions encountered during operation may be different than design assumptions, for example:
 - Differences in occupancy and daily flows
 - Differences in business functions and wastewater characteristics
 - * Operation and maintenance may be inadequate, e.g.:
 - Failure to repair a malfunctioning pump or aerator

2.28



- Treatment achieved by each system or all systems?
 - Focusing on each and every system in a given area
 - Specifying that the treatment efficiency of each system must meet requirements (e.g., individual system average TIN < 10 mg-N/L)
 - Could be the best approach where local risk is high, e.g.:
 - * Contamination of groundwater used for drinking water
 - * Aquatic toxicity from discharges to sensitive surface waters
 - Focusing on a population of systems in a given area
 - Specifying that the treatment efficiency of a population of systems must meet requirements (e.g., population wide average TIN < 10 mg-N/L)
 - Could be the best approach where local risk is not high but there is a collective risk, e.g.:
 - * In a watershed where there are concerns over cumulative effects on sensitive surface waters

2.29



2-4. Sustainability Attributes

- Sustainability of a system is often important to a project and this can be assessed with respect to:
 - Long-term, reliable treatment performance
 - Affordable costs for construction and operation
 - Acceptably low resource requirements and impacts
- Long-term, reliable treatment performance
 - A sustainable system should have predictable reliability during the design life of the project
 - System reliability is determined by proper system selection and design and implementation, including:
 - Use of redundancy and parallel treatment trains for larger flows
 - Provision of all requisite operation and maintenance
 - Use of on-line, real time monitoring and process control

2.30



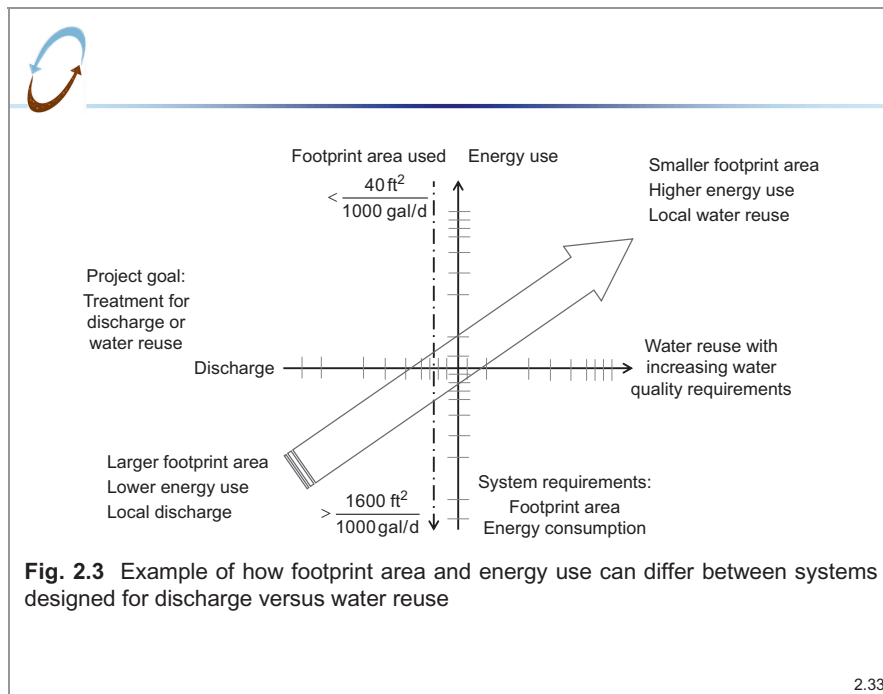
- Affordable costs for construction and operation
 - A sustainable system must be affordable
 - Affordability includes one-time capital and recurring annual costs
 - Capital costs result from system design, construction and startup
 - Annual costs result from routine operation and planned, or otherwise required, maintenance activities
 - Economic analysis can be used to assess the net present value (NPV) of a particular system
 - $NPV = \text{capital costs} + \text{amortized annual costs}$ based on an assumed interest rate
 - In some situations, project owners can have a preference for a system with low capital costs and higher recurring annual costs even though the NPV could be higher for this latter system

2.31



- Acceptable resource requirements and impacts
 - A sustainable system must have acceptable resource attributes
 - Different systems typically have different resource attributes
 - Water—interior use by fixtures and appliances and exterior use for washing and irrigation functions
 - Nutrients—N, P, K are present at high levels in wastewaters
 - Energy—used to produce and deliver drinking water and collect and treat wastewater and used for heating water
 - Chemicals—used in consumer products for washing and cleaning, and for treatment of water and wastewaters
 - Materials—plastics, metals, and other materials used to construct water and sanitation systems
 - Resource attributes, including requirements, can be dependent on project goals and treatment efficiency requirements as illustrated in Fig. 2.3

2.32



2.33

-
- More sustainable systems with respect to environmental impacts tend to minimize resource use directly or via recovery
 - More sustainable systems minimize environmental impacts due to resource use during wastewater collection and treatment
 - Systems can be configured that meet treatment efficiency needs and have relatively lower resource requirements
 - * Different unit operations are listed in Table 2.7 along with their relative resource requirements for:
 - Land and site
 - Water
 - Power
 - Chemicals
 - O&M labor and materials
 - Capital and operating costs
 - Systems can also be configured to benefit from the resource attributes of water use efficiency and source separation approaches (Table 2.8)

2.34

**Table 2.7** Example treatment unit operations and their relative resource requirements

Treatment unit operation	Resources and example relative requirements ^a					
	Land and site	Water	Power	Chemicals	O&M	Costs
Septic tank units	1	1	0	0	0	1
Aerobic treatment units	1	1	2	0	1	1, 2
Intermittent sand filters	2, 3	1	1	0	1	1, 2
Recirculating biofilters	1, 2	1	1	0	1	2
Membrane bioreactors	1	1	3	0	2	3+
Constructed wetlands	3	1	0, 1	0	0	2
Infiltration soil treatment units	3	1	0, 1	0	0	1
Landscape drip dispersal	3	1	1	0	0, 1	1, 2
Nutrient removal biofilter units	2	1	0, 1	0, 1	0, 1	1, 2
Disinfection units	1	1	1	0, 1	1	1, 2

^aNumbers are given as examples only to indicate relative req.: 0 = none; 1 = low; 2 = moderate; 3 = high.


2.35

**Table 2.8** Resource attributes of water use efficiency and source separation approaches

Approach	Example resource use avoided directly or by recovery ^a				
	Water	Energy	Nutrients	Chemicals	Materials
Water efficient fixtures and appliances for flow reduction	3	1, 2	0	0, 1	0, 1
Source separation for urine diversion	0, 1	1	3	0, 1	0, 1
Source separation for graywater treatment, recycling or reuse	1, 2	0, 1	0, 1	0, 1	0, 1
In-source water recycling of reclaimed water	2, 3	0, 1	0, 1	2, 3	0, 1
Local water reuse of reclaimed water	2, 3	1, 2	2, 3	1, 2	1, 2

^aNumbers are given as examples only and indicate relative degree of resource use avoided: 0 = none; 1 = low; 2 = moderate; 3 = high.

2.36



2-5. Configuring Viable Systems

- Configuring viable systems requires thoughtful consideration of project goals and requirements
 - Many, if not most, projects involving decentralized infrastructure involve configuring a viable treatment train from available unit operations
 - Table 2.9 presents example treatment trains and systems that might be configured for a particular project goal and set of requirements
 - A generalized decision diagram is given in Fig. 2.4 and then used in Figs. 2.5, 2.6, 2.7, 2.8, and 2.9 to illustrate example treatment trains for different project goals and requirements
 - Source separation options within buildings can also enable system configurations that satisfy goals and requirements (Fig. 2.10)

2.37


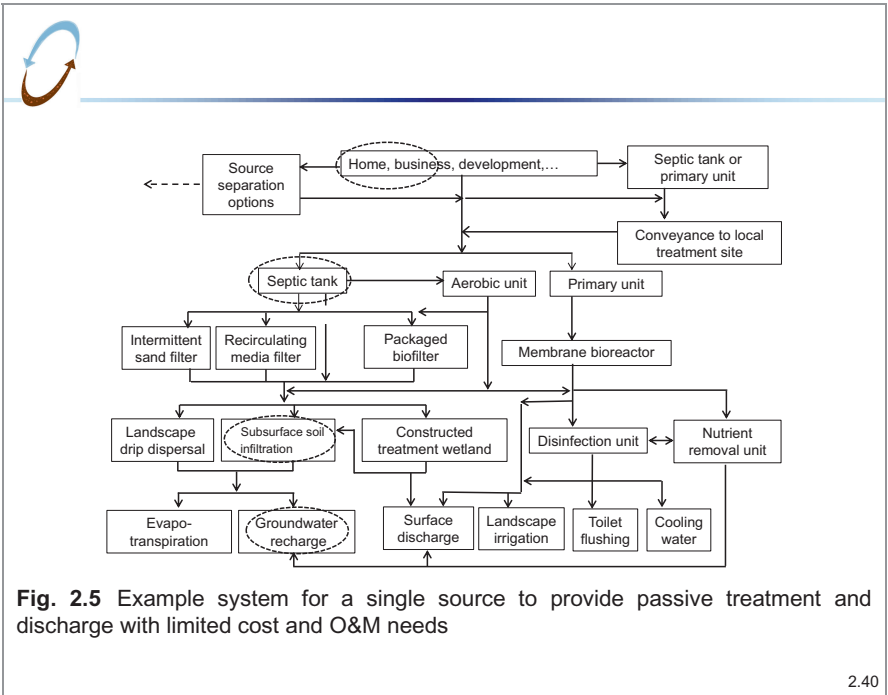
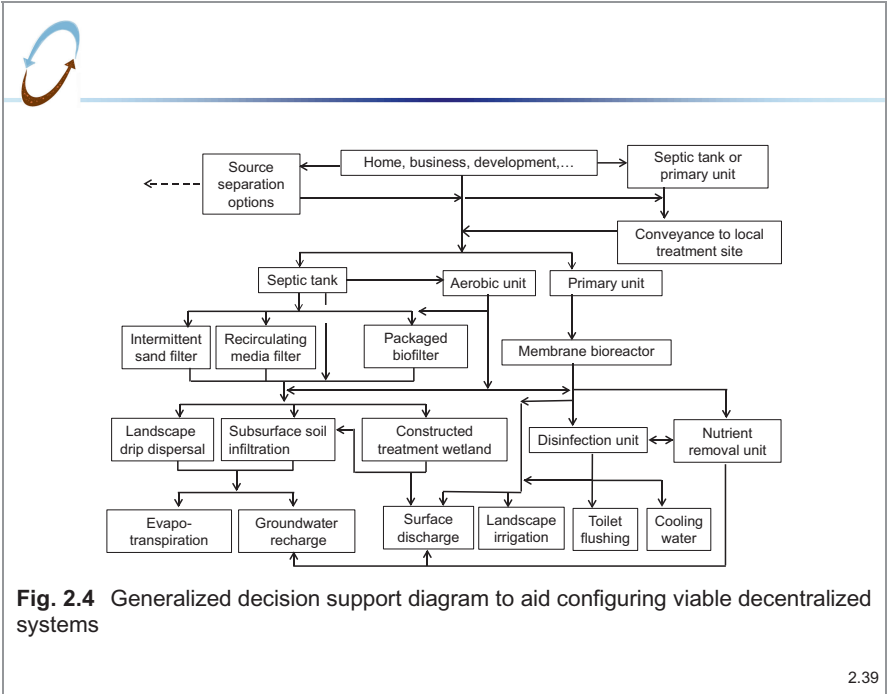


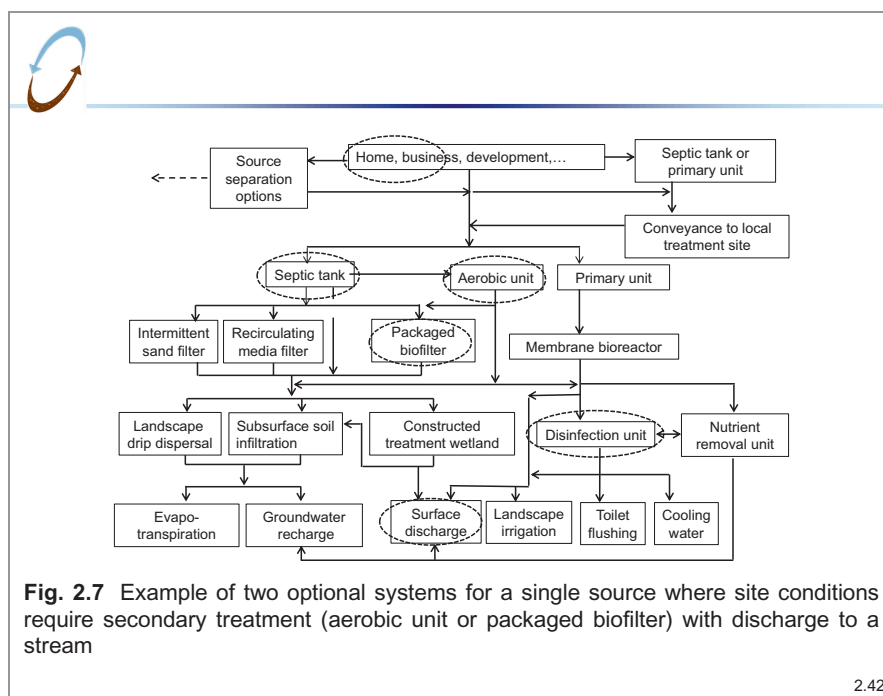
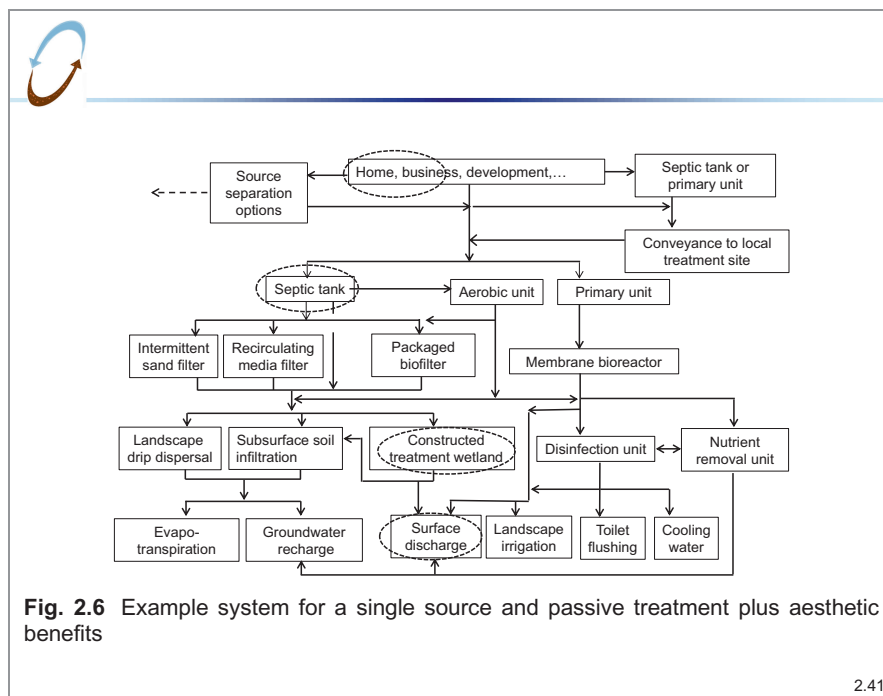
Table 2.9 Examples of typical system configurations for common goals and requirements for projects serving homes or businesses

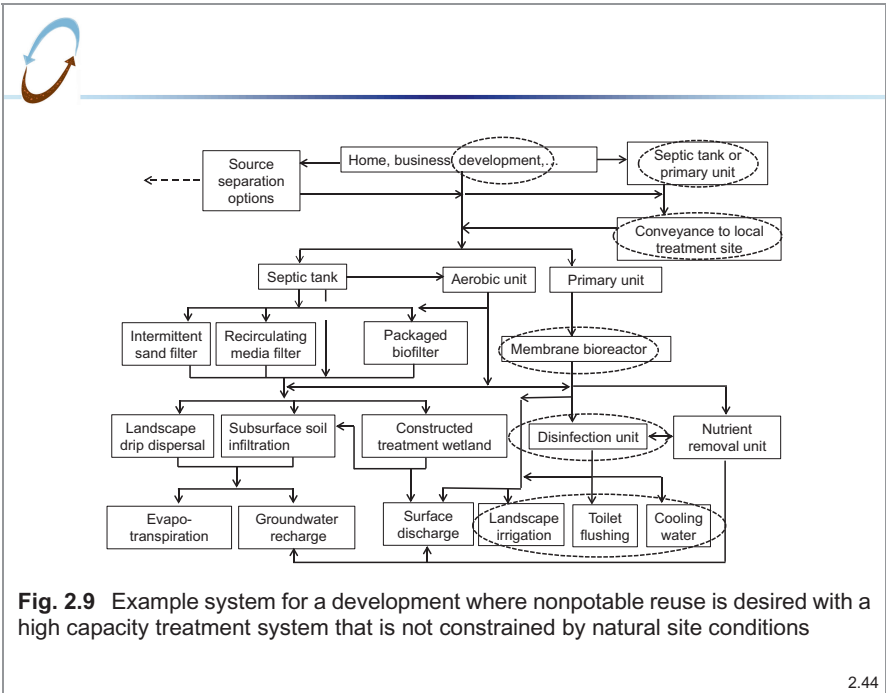
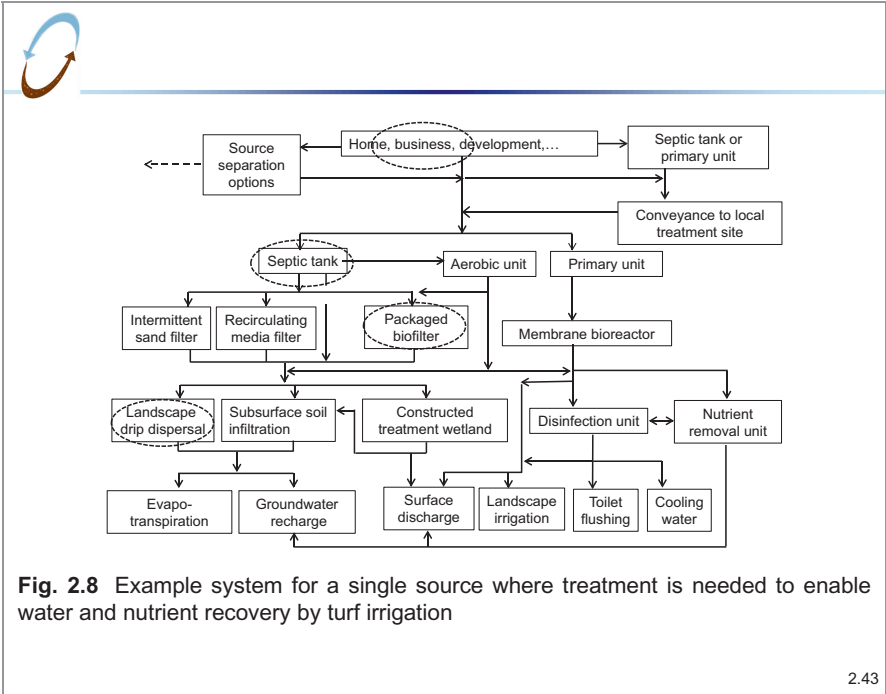
Project goals/requirements	Example treatment train and flow scheme
Treatment and safe subsurface discharge with a passive or low input system	Septic tank → Subsurface soil infiltration → Groundwater recharge
	Septic tank → Packed bed biofilter or Aerobic treatment unit → Landscape drip dispersal → Evapotranspiration
	Septic tank → Aerobic treatment → Mounded soil infiltration → Groundwater recharge
Treatment and safe discharge to the surface with a passive or low input system	Septic tank → Constructed wetland → Discharge to a bog or stream channel
Treatment and safe discharge to a sensitive surface water	Septic tank → Packed bed biofilter or Aerobic treatment unit → Chlorine or UV disinfection → Discharge to a stream or river
	Septic tank → Packed bed biofilter → Denitrifying biofilter → Chlorine or UV disinfection → Discharge to a nutrient limited lake or estuary
Treatment and nonpotable reuse	Primary settling → Membrane bioreactor → UV disinfection → Toilet flushing and turf irrigation

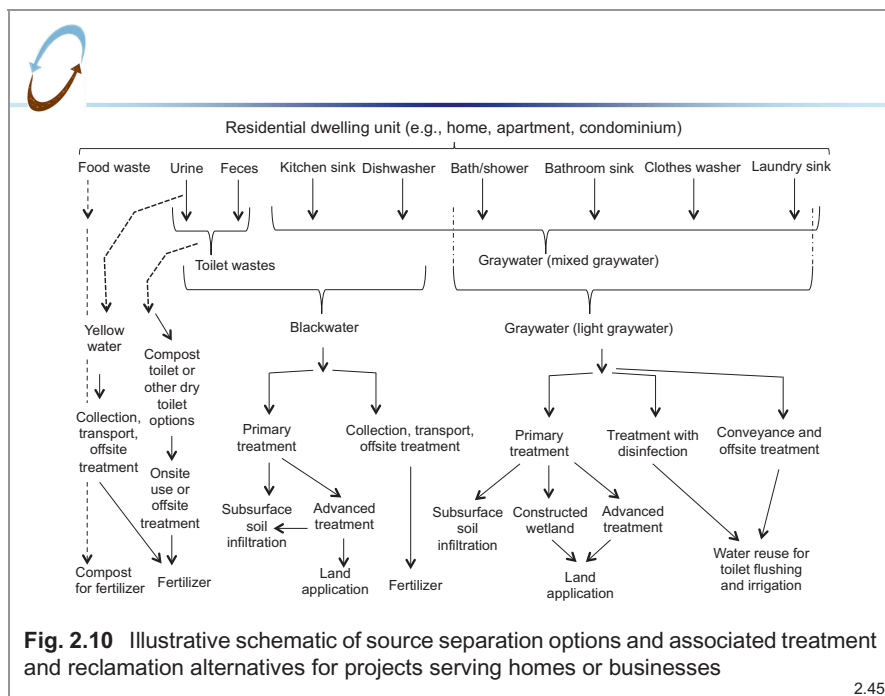
Note: The project goals/requirements and treatment trains shown are examples only.

2.38

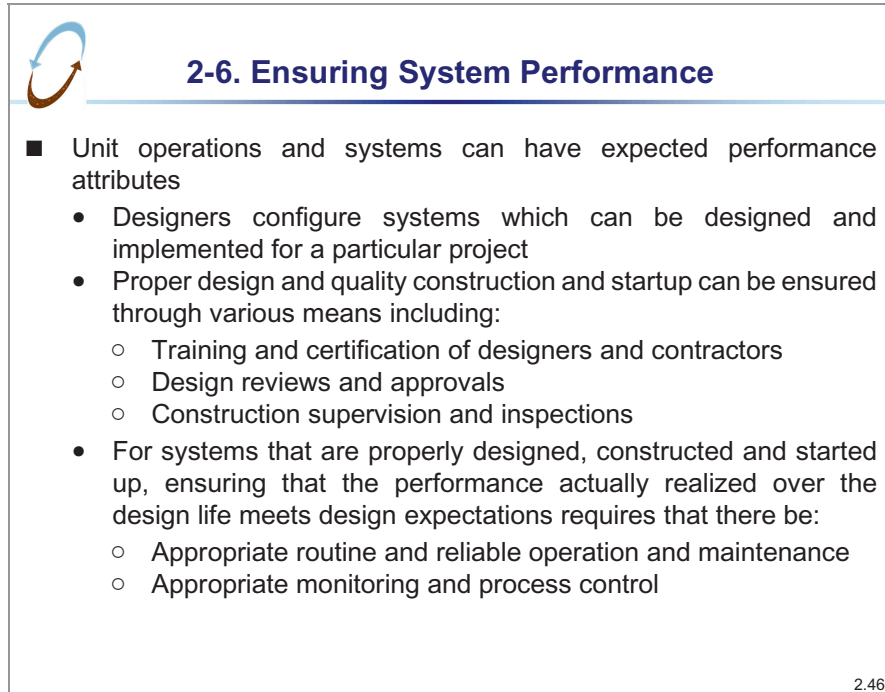








2.45



2.46



■ Operation and maintenance

- O&M requirements vary in complexity and frequency, e.g.:
 - Inspections of system operations (e.g., flow readings, pumps and aerators functioning, etc.)—e.g., every 0.5–1 year
 - Pumping of residuals (e.g., from septic tanks)—e.g., every 5 years
 - Cleaning or replacement of media (e.g., in porous media biofilters)—e.g., every 10 years or more
- O&M required versus complexity is illustrated in Fig. 2.11

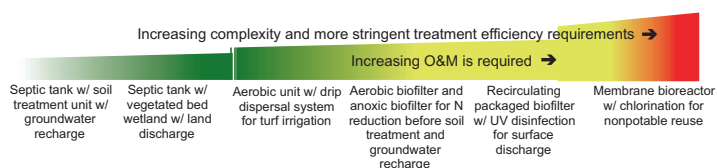


Fig. 2.11 Illustration of O&M requirements as a function of system complexity and treatment efficiency requirements of a particular project

2.47



■ Monitoring

- The need for, and importance of, monitoring depends on system complexity and the impacts of performance deficiencies should they occur (Fig. 2.12)
- Monitoring methods can be used to determine the following:
 - Operational status of a unit operation or system, e.g.:
 - * Is the circuit providing power to a dosing pump energized?
 - * Is the lamp intensity in a UV disinfection system okay?
 - Treatment performance of a unit operation or system, e.g.:
 - * Is the concentration of *E. coli* ≤ 10 org per 100 mL?
 - * Is the total N in the groundwater ≤ 10 mg-N/L?
- Examples of monitoring data to assess system operational status and performance are summarized in Tables 2.10 and 2.11

2.48

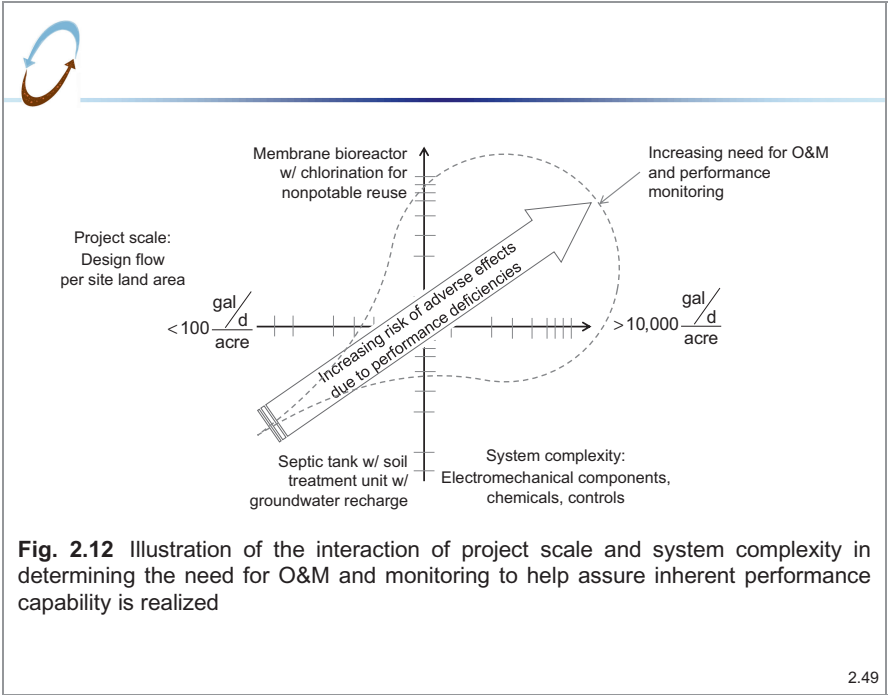


Table 2.10 Examples of data types that provide information on system operation

Data type	Data uses	Methods	Relative difficulty to obtain data
Power supply	Verify powered equipment is energized	Power meter	Low
Pressure	Provide insight into blockages in pipelines and piping networks or to liquid levels in tanks	Gages; Transducers	Low
Temperature	Provide insight into freezing conditions or rates of reactions	Thermocouples; thermometers	Low
Flow rate (daily)	Compare actual flow to design flows to determine if unit operation or system is under- or over-loaded hydraulically	Flow meters for continuous flows; Cycle counters on batch flow events	Low
Event cycles	Verify operation of batch events (e.g., siphon discharge, timed dosing events)	Mechanical or electrical counters	Low

2.50



Table 2.11 Examples of data types that provide information on system treatment performance

Data type		Data uses	Methods	Data type and difficulty and cost
Effluent water quality	A. Routine parameters (e.g., pH, alkalinity, BOD ₅ , TSS, N, P, Fecal coliforms)	Verify quality is consistent w/design values and/or permit reqt.	Grab sampling and analysis	A. Low
	B. Advanced analyses (e.g., virus, trace organics)		Composite sampling and analysis; in-line chemical sensors	B. Moderate–High
Soil pore water and ground-water	A. Routine parameters (e.g., pH, alkalinity, DOC, BOD ₅ , TSS, N, P, <i>E. coli</i> .)	Verify land-based treatment units are performing per design and/or permit reqt.	Soil suction lysimeters or soil coring for sampling and analysis	A. Moderate–High
	B. Advanced analyses (e.g., virus, trace organics)		Groundwater probes or wells; sampling and analysis; in situ sensors	B. High
Surface water	A. Routine parameters (e.g., pH, alkalinity, DOC, BOD ₅ , TSS, N, P, <i>E. coli</i> .)	Verify absence of effects on surface water quality	Grab sampling and analysis	A. Low
	B. Advanced analyses (e.g., virus, trace organics)		Composite sampling and analysis; in situ chemical sensors	B. Moderate–High

2.51



- Automated and real-time monitoring
 - This can be very important for decentralized infrastructure
 - Devices and technologies for data acquisition include:
 - * In-line and in situ flow and chemical sensors
 - * Alarms and control devices
 - * Programmable logic controllers
 - * Data loggers
 - * Auto dialers
 - * Telemetry systems
 - Supervisory control and data acquisition (SCADA) systems
 - * SCADA systems can be used to gather and analyze real-time data to monitor and even control a unit operation or system

2.52



- Reasonable, appropriate and affordable monitoring
 - Operational and performance (O&P) data should provide information that is useful, if not, critical for decision making
 - O&P data should be reasonable and appropriate based on:
 - * System configuration and complexity
 - * Performance effects of operational departures from design
 - * Risks associated with inadequate operation or performance
 - Adequate resources need to be allocated to generate sound O&P data for the intended information and decision-making purposes

2.53



2-7. Management Systems

- Management is essential to proper selection, design, and implementation of decentralized infrastructure
- What is meant by “management systems”?
 - Management systems involve entities and activities, often organized within a jurisdiction, to assure:
 - Decentralized systems are properly considered during infrastructure and land use planning, and
 - If selected they are properly designed, constructed, and operated so performance is satisfactory over a long-term planning period
 - As decentralized systems have evolved to become a permanent part of the wastewater infrastructure in the U.S., the need for, and critical role of, management has also evolved
 - According to USEPA (2002), “Management is the key to ensuring that the requisite level of environmental and public health protection for any given community is achieved.”

2.54




- Characteristics of successful management programs
 - Successful programs often have key elements:
 - Clear and specific program goals
 - Public education and outreach
 - Technical guidelines for site evaluation, design, construction, O&M for conventional and alternative options
 - Regular system inspections, maintenance and monitoring
 - Licensing or certification of all service providers
 - Adequate legal authority, effective enforcement mechanisms, and compliance incentives
 - Adequate record management
 - Periodic program evaluations and revisions
 - Available funding mechanisms

2.55



- A successful management program may have multiple agencies or entities involved
 - Federal, state, and tribal agencies
 - Local governments: county, township, village, or city
 - Special-purpose districts and public utilities
 - Privately owned and operated management entities
- Regardless of the entities involved, a successful program will have elements that are:
 - Publicly accepted
 - Politically feasible
 - Fiscally viable
 - Measurable
 - Enforceable

2.56



■ Management models for decentralized systems and different situations

- USEPA (2003, 2005) developed five models that address different levels of risk determined by site- and system-specific considerations
 - The five management models include:
 - * Owner awareness
 - * Maintenance contracts
 - * Operating permits
 - * Responsible management entity (RME) O&M
 - * RME ownership, O&M and management
 - “Risk factors” (Table 2.12) influence the type of management needed as illustrated in Fig. 2.13

2.57


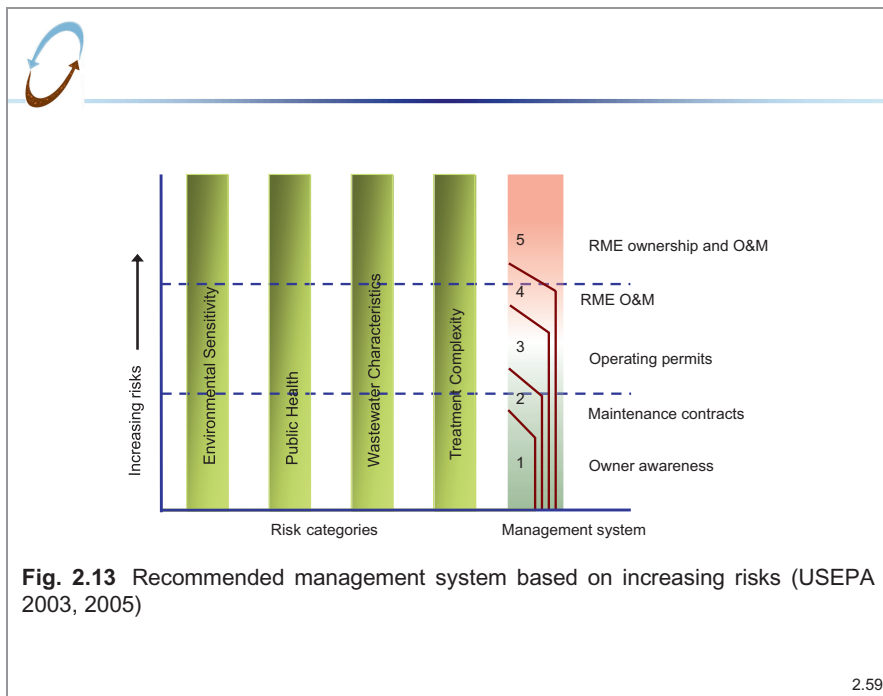


Table 2.12 Risk categories and factors that influence the type of management system needed for a given project or jurisdiction (USEPA 2003, 2005)

Risk category	Example factors that can lead to higher risk conditions ^a
<ul style="list-style-type: none">• Environmental sensitivity	<ul style="list-style-type: none">• Impermeable soils such as heavy clay• Shallow depths to groundwater• Rock layers near the surface• Hilly terrain with thin soils and steep slopes• High densities of system installations• Sensitive waterbodies nearby
<ul style="list-style-type: none">• Public health	<ul style="list-style-type: none">• Drinking water wells nearby• Recreational waters nearby• Effluent surfacing or plumbing backups• Potential for rapid groundwater movement• Systems more than 25 years old not maintained• Illegal system discharges
<ul style="list-style-type: none">• Wastewater characteristics	<ul style="list-style-type: none">• Heavy sewage loads (high-strength wastewaters)
<ul style="list-style-type: none">• Treatment complexity	<ul style="list-style-type: none">• Industrial and certain commercial wastewaters• High fat, oil, and grease content in wastewater• Electrical and mechanical system components

^aThese risk categories and factors are focused on decentralized systems that utilize land-based treatment operations including legacy leachfields, drainfields and soil absorption systems.

2.58



2.59

2-8. Summary

- Decentralized infrastructure is selected, designed and implemented for a particular project to satisfy project goals and requirements
- Achieving the performance capabilities of a unit operation or system requires proper design, construction and startup along with appropriate operation and monitoring
- Monitoring can help assess operation status and verify performance achievement, but it needs to be reasonable, appropriate, and affordable based on conditions and risks
- Management is essential to ensure proper selection, design, and implementation of decentralized systems that can and will achieve a desired performance in a sustainable manner

2.60

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