

Manual of Water Supply Practices

M24

Planning for the Distribution of Reclaimed Water

Fourth Edition



American Water Works
Association



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Manual of Water Supply Practices — M24, Fourth Edition

Planning for the Distribution of Reclaimed Water

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Preface



This publication is the third revision of the original AWWA Manual M24, *Dual Water Systems*, published in 1983. In the second revision, the title was changed to *Planning for the Distribution of Reclaimed Water* to better represent the content of the manual. This fourth edition builds upon that wholesale change in the manual and provides updates and additional information on the planning and design of dual distribution systems for appropriately treated reclaimed water (nonpotable water) for applications that do not require potable-quality water.

The distribution of reclaimed water using dual water distribution systems—one for potable water and the other for nonpotable water—is now a widely accepted practice. The drivers for the increasing use of reclaimed water are diminishing supplies of high-quality water resources, escalating costs for developing new sources or for treating poor-quality water to potable-water standards, and the increasing costs associated with discharging wastewater to the environment.

When faced with the task of developing additional water sources, utility managers and design engineers are increasingly evaluating the potential for distributing reclaimed water to serve their community's needs. Properly treated and distributed nonpotable water, as defined herein, can safely be used for irrigation, industrial applications, and a wide range of other nonpotable urban purposes, including toilet flushing in high-rise commercial and residential buildings. Developing a reclaimed-water distribution system may be less costly and less wasteful than existing practices that use potable water for purposes that do not require such high-quality water. In recent years, there has been a growing interest in smaller dual distribution systems using reclaimed water from distributed water-reclamation facilities within a utility's service area. This concept is introduced in this manual.

National standards for the distribution and use of nonpotable water have not been established; however, the US Environmental Protection Agency (USEPA) updated its Guidelines for Water Reuse in 2012. As of 2018, 22 states have regulated standards for the distribution and use of nonpotable water, and 25 other states have some form of regulation (9) or guidelines (16) related to the production of reclaimed water. The AWWA Water Reuse Committee, which prepared this manual, provides the information in this manual for water systems wishing to distribute reclaimed water. Water utilities should consult state and local regulatory agencies before designing a nonpotable-water distribution system, as state and local regulations may impose requirements that differ from the recommendations in this manual.

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Acknowledgments

This fourth edition of the AWWA Manual M24, *Planning for the Distribution of Reclaimed Water*, was prepared by members of the Water Reuse Committee of the AWWA Water Resources Sustainability Division. Alan Rimer of EnviroTechNovations LLC (retired from Black & Veatch) served as Chair. There were many contributors to this manual. Some wrote full sections, while others contributed extensively by providing materials for the manual and/or through their thorough review of the document. The Chair and AWWA Staff are very grateful for all of the effort that went into the creation of this fourth edition.

Specifically, the following were primarily responsible for various chapters of the manual:

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David Ammerman, Thomas Bell-Games, Jim Crook, Venkatraman Radhakrishnan, and Peter Rogers provided information and/or editorial guidance on the final document. Many members of the AWWA Water Reuse Committee provided input to the manual along the way.

AWWA staff were most helpful. Sue Weikel took up the project midway through the effort and was instrumental in moving this publication along. Alex Gerling provided technical editorial guidance.

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Chapter **1**

Introduction

Since 1983, when the first edition of this American Water Works Association (AWWA) manual was published, many water and wastewater utilities, communities, authorities, states, and countries have implemented dual water distribution systems, particularly in light of the increased emphasis on higher degrees of wastewater treatment. These water-reclamation facilities can significantly increase the availability of reclaimed water for use as described in this manual. They provide reclaimed wastewater to a variety of customers, making the most of all their available water resources. The International Water Association in London lists, in addition to the United States, Australia, and the United Kingdom, 13 other countries that have strong programs in dual water distribution and water reclamation. Assessing the growth of water reclamation and the adoption of dual water distribution systems for communities large and small has been a difficult task as their growth seems to be almost exponential. What is appreciated worldwide is that wastewater reclamation and dual water distribution systems are an important consideration for communities as they search to expand their water supply resource(s).

This manual discusses the planning, design, construction, operation, regulatory framework, and management of community dual water distribution systems, which consist of separate systems for distributing potable water and nonpotable water principally drawn from reclaimed wastewater specifically for use in such dual distribution systems. Increasingly, there is the potential for potable reuse, which is discussed in various locations throughout this manual. Reclaimed water treated to potable-water standards is not distributed in a dual distribution system.

DEFINITIONS

- *Advanced water purification facility (AWPF):* A water purification facility that through a series of unit operations produces a purified potable-water source suitable for use as a potable-water supply from the supply water from a water resource recovery facility (WRRF), a raw water supply, or a combination of both.

- *Dual distribution systems*: Two separate water distribution systems conveying water to customers, one carrying potable water and the other conveying lesser-quality water (e.g., nonpotable reclaimed water) for reuse purposes.
- *Direct potable reuse*: The supply of advanced purified reclaimed water directly into potable-water supply lines, potable-water treatment plants, and/or drinking water transmission or distribution systems.
- *Indirect potable reuse*: Includes augmenting raw potable-water supplies with advanced purified water indirectly through storage and transmission through an environmental buffer.
- *Nonpotable water*: Water that is considered unsafe, unpalatable, or both for drinking. Other sources of nonpotable water may include brackish or mineralized surface waters and groundwaters, including seawater, certain industrial wastewaters, fracking wastewaters, stormwater runoff, polluted natural waters, and irrigation return flows.
- *Potable water*: Water that is safe and satisfactory for drinking and cooking.
- *Reclaimed water*: Treated domestic wastewater (among other sources) that is used for a variety of purposes before it passes back into the water cycle. Reclaimed water may also be referred to as recycled water.
- *Water resource recovery facility (WRRF)*: A wastewater treatment facility employing primary, secondary, and tertiary treatment for the production of reclaimed water or as a supply water for an AWWPF (see below).

HISTORY

The concept of dual systems is not new, having been adopted by Augustus about 2,000 years ago. Water from one of the hills near Rome was found to be highly poisonous, but it was still used to feed the many fountains of Rome and for many other nonpotable uses. In 1911, W.T. Sedgwick of the Massachusetts Institute of Technology read a paper to the New England Water Works Association titled “Has the Time Come for Double Municipal Water Supplies, One—Naturally Pure—for Drinking and Cooking, the Other—Denatured or Sterilized—for All Other Purposes?” (Sedgwick and Letton 1911). This was the advent of the period when dual distribution was at least recognized in the United States.

The basis of the adoption of water reclamation and dual distribution systems stands on a firm foundation dating back to the late 1950s. The policy affirming this approach was enunciated by the United Nations Economic and Social Council, which stated, “No higher quality water, unless there is a surplus of it, should be used for a purpose that can tolerate a lower grade” (United Nations Economic and Social Council 1958). For public drinking supplies, it is AWWA’s policy that the highest quality sources be used (Drinking Water Quality Policy Statement adopted by the AWWA Board of Directors Jan. 24, 1988, and revised Jan. 29, 1989; Jan. 23, 2000; June 15, 2003; Jan. 21, 2007; June 9, 2013; and Jan. 14, 2017).

With population growth and urban and industrial development throughout the world and with most high-quality sources of substantial yield already developed, surpluses of high-quality water for the future are being exhausted. Using wastewater treatment plant effluent for industrial, urban, or agricultural irrigation purposes is one way a nonpotable supply can lessen the demand on potable water. An example is the introduction of wastewater treatment plant effluent for use in the steel industry in Baltimore, Md., over a century ago (Okun 1973). Another example is the distribution of reclaimed wastewater to several industries in Colorado Springs, Colo., in 1960 to relieve the demand on limited freshwater resources.

Substitution of lower-quality water for nonpotable purposes to preserve limited resources of high-quality water remains one of the primary purposes of dual distribution systems. For example, seawater has been used extensively for decades for toilet flushing in commercial and multifamily residential buildings in Hong Kong to preserve limited freshwater resources.

The first dual distribution system illustrating the potential for the future was built in 1926 for the Grand Canyon Village in Arizona, which is on the south rim of the Grand Canyon and had become a fast-growing community with the El Tovar Hotel at its center. The village had virtually no rainfall, and water had to be carried by train and other vehicles as other sources such as groundwater were not available. In 1926, a source of fresh water was found north of the Colorado River, which was pumped to the village to serve the hotel and other facilities. When it was recognized that the resulting treated wastewater produced in the village might be applied usefully, these treated wastewaters were circulated in a dual distribution system, thus originating the first purposeful water-reclamation system and dual distribution system in the United States.

In the 1950s, at meetings of the National Research Council's committee on sanitary engineering and the environment, Gordon M. Fair of Harvard suggested dual water supplies. In 1965, Paul Haney enhanced the idea in the first published article on dual systems. These were the two most widely circulated publications encouraging the construction of dual systems at the time.

Two factors have accelerated the development of dual distribution systems. First is the need for water supplies that do not necessarily need to be of potable quality for urban and industrial use. Second are new requirements for costly, advanced wastewater treatment, including nutrient and organics removal, to protect receiving waters. Using reclaimed water for nonpotable purposes may reduce treatment costs when nutrient removal is not only unnecessary but wasteful. This is the case for urban and agricultural irrigation because nutrients already in the wastewater can replace those that would ordinarily need to be added (Figure 1-1). An extensive distribution system for urban irrigation, including the watering of parks, campuses, median strips, and residential lawns, is an important element of a reclaimed-water system used for other nonpotable purposes.



Figure 1-1 Crop irrigation with reclaimed water

POTENTIAL DRIVERS FOR DUAL DISTRIBUTION SYSTEMS

With numerous successful dual water distribution systems now in operation, ranging from systems that serve only one or two major customers to systems that serve almost all properties in a community, water supply professionals are now considering dual distribution systems for addressing water supply needs, water pollution-control problems, or both. Reclaimed water is the “new” water resource. There are many drivers that a community will consider when developing a plan for assessing the feasibility of dual distribution. Such drivers range from conservation to limited water resources.

Conservation

Before any concerted effort is made to find additional water resources for a community or to build costly dual distribution systems, water conservation is the utility’s first approach to reduce water consumption. Wasteful water practices, such as the use of older high-volume flush toilets, inefficient local landscaping practices, and water rates that encourage high water consumption, must be carefully examined by the utility and its customers. As might be expected, communities have had varying degrees of success in reducing water consumption through conservation practices. AWWA has a manual on conservation strategies entitled [M52](#), *Water Conservation Programs – A Planning Manual*, the second edition of which was published in 2017.

Limited Water Resources

Competition for existing water resources or limitations on these resources often make acquisition or expansion of additional water resources politically and financially difficult. For example, obtaining additional water resources might require interbasin (raw water) transfer, which is currently less politically acceptable than it was in the earlier years of water resources development. The specter of climate change and its potential implications for urban water utilities has added to this mix of uncertainty. Consideration must also be given to downstream users impacted by water rights issues and stream flows where applicable. Greater knowledge of groundwater hydrology has illuminated the concerns associated with excessive withdrawals from aquifers, which result in increasing costs of pumping, impaired water quality, and land subsidence. Limited new water resources create a situation in which water reclamation and a dual distribution system may become attractive.

Limited Water Supplies

When demand is expected to exceed the yield from existing water supply facilities and additional facilities need to be constructed, the gradual introduction of a nonpotable system might be appropriate. Water users, whether industrial, commercial, or municipal, may well be served with reclaimed wastewater in place of potable water at a cost that is generally lower than the cost of developing new high-quality sources of supply for potable purposes.

Polluted Sources

The 1962 US Public Health Service Drinking Water Standards recommended that “water supply should be obtained from the most desirable source which is feasible” (USPHS 1962). US Environmental Protection Agency (USEPA) National Interim Primary Drinking Water Regulations adopted in 1974 state that “priority should be given to the selection of the purest source.” Many communities have selected the highest-quality source

available, and additional development may require use of a lesser-quality source. In the past, engineers believed that they could render most polluted water safe for potable supply through adequate treatment, generally consisting of coagulation, filtration, and disinfection. However, the chemical revolution following World War II resulted in the creation of thousands of synthetic organic chemicals that are not readily degraded in the environment or easily treated. The number of contaminants regulated in potable water has grown from four in 1925 to 103 primary and secondary contaminants in 2009 (the latest listing), with more regulations anticipated (USEPA 2009, Calabrese 1989). The treatment of water that will meet drinking water standards in the future may cost considerably more than it currently does. Degraded sources may therefore be less suitable for potable-water supplies but well-suited for one or more nonpotable purposes.

Rigorous Wastewater Treatment

To restore and preserve the quality of North American waters, treatment requirements for municipal and industrial wastewaters have become increasingly stringent and costlier. Treatment processes also have become increasingly more complicated, with nutrient removal almost always required for the major utilities that are most likely to adopt water reuse. Various treatment options can be employed to achieve a quality of reclaimed water that can be used in a dual distribution system. For example, filtration is generally employed in modern reclaimed-water facilities. The operation and maintenance of advanced physical and chemical wastewater treatment facilities are generally costlier than treatment for nonpotable reuse. If wastewater can be used productively, the savings in wastewater treatment can be passed on to users, making water reclamation and dual distribution systems more economically attractive.

POTENTIAL USES FOR RECLAIMED WATER

A dual distribution system is most appropriate when the nonpotable water can be used in a community. Examples include the following, which require varying levels of treatment.

Public uses:

- Park irrigation
- School campus landscaping and playground irrigation, median strips, and roadway right-of-way landscaping irrigation
- Recreational facilities, such as golf course irrigation (Figure 1-2) and tennis court wetting and washing
- Aesthetic impoundments (fountains, water features, etc.)
- Cemeteries and plant nurseries
- Firefighting (Figure 1-3)
- Toilet and urinal flushing

Industrial and commercial uses:

- Cooling-tower makeup water
- Boiler feedwater makeup water
- Stack gas scrubbers
- Process waters
- Construction, including concrete manufacture, soil compaction, and dust control
- Toilet and urinal flushing
- Cleaning and car washing



Figure 1-2 Irrigation with reclaimed water at a North Carolina golf course



Figure 1-3 Firefighter using reclaimed water

Agricultural uses:

- Restricted-access area irrigation
- Processed food crops
- Non-food crops
- Groundwater recharge with restrictions
- Sod farms
- Silviculture

Residential uses:

- Lawn watering
- Toilet flushing (in many states)

NONPOTABLE-WATER REUSE LEGISLATION

In some states, such as California, Florida, Arizona, and North Carolina, nonpotable-water reuse is prompted through legislation. The following paragraphs provide an introduction to the history of such legislation.

California

California has long recognized the benefits associated with reclaimed-water reuse. The state legislature declared that a substantial portion of future water requirements can be met economically through the beneficial use of reclaimed water. The legislature intends for the state to take all possible steps to encourage development of water-reclamation facilities so that reclaimed water may be made available to help meet California's growing water requirements. Statutes added since 1973 prohibit the use of water from any suitable potable-water source for the irrigation of greenbelt areas, including golf courses, cemeteries, parks, and highway landscaped areas, when suitable reclaimed water is available. Additional uses have been added through subsequent legislation. Reclaimed water is considered suitable under the following conditions:

- The reclaimed-water source is of adequate quality for such use and is available;
- The reclaimed water can be provided to such greenbelt areas at a reasonable cost;

- Reclaimed-water use will not be detrimental to public health;
- Reclaimed-water use will not affect downstream water rights, will not degrade water quality, and is determined not to be injurious to plant life.

During the last 30 years, wastewater reclamation has been encouraged further by the Office of Water Recycling (OWR), a division of the California State Water Resources Control Board. OWR promotes treated wastewater reuse, identifies potential projects, and provides financial assistance with water reuse projects (California State Water Resources Control Board 1985). The growth of the use of reclaimed water has been fostered through a variety of legislative actions and rulemaking by OWR and other agencies.

Florida

Although rainfall averages approximately 59 in. (150 cm) per year in Florida, potable-water resources are limited. The Florida Department of Environmental Regulation has declared as policy that the state will “advocate and direct the reuse of reclaimed water as an integral part of water management programs...consistent with protection of the public health and groundwater quality” and “encourage the use of water of the lowest acceptable quality for the purpose intended” (Florida State Legislature 1988). This policy is expressed in the rules of the Southwest Florida Water Management District that state, “before a consumptive use permit (for water abstraction) is issued, consideration will be given to the lowest quality water which the applicant can use, (and if) such water is available, the consumptive use permit will be issued only for the use of the lower quality water” (Southwest Florida Water Management District 1985). More recently, the State of Florida passed a bill requiring a reevaluation of the discharge of wastewater into the ocean (State of Florida 2008). This law has significantly expanded the number of water-reclamation facilities and in turn dual distribution systems for conveying the available reclaimed water to an expanding customer base.

Arizona

Groundwater overdraft has lowered water levels by as much as 400 ft (122 m), resulting in increased pumping costs, degraded water quality, and land subsidence. The use of reclaimed water in Arizona is encouraged through several state laws that resulted from various historical events. In 1948, the US Secretary of the Interior advised Arizona that a comprehensive state groundwater management code was a prerequisite to federal authorization of the Central Arizona Project (a massive US Bureau of Reclamation project to bring Colorado River water to central Arizona irrigation districts and municipalities). In 1990, the legislature adopted the Groundwater Management Act (Arizona Administrative Code 1990a), which identified areas requiring implementation of specific water conservation programs to balance groundwater withdrawal and demand by 2025. Other legislative initiatives have resulted in stringent conservation, particularly of groundwater resources.

Critical in achieving the state’s water conservation goals is the reclamation of municipal wastewater. In response to mandated municipality-specific, per capita water-use targets based on a phased conservation program, some Arizona cities have developed dual water distribution systems. Filtered and disinfected reclaimed water is purchased in some areas at rates equal to that for potable water. Some cities require the use of reclaimed water on all new golf courses and parks and are considering mandatory retrofit for these irrigation uses.

The Arizona Department of Water Resources has provided further incentives for water reclamation by not including reclaimed water in calculating the average per capita municipal demand. Recent legislation authorizing underground storage and recovery provides a mechanism for subsurface storage to accommodate seasonal demands for

irrigation water typical of the arid Southwest (Arizona Administrative Codes 1990b, 1990c). Legal disputes over the identity and ownership of reclaimed water and water quality considerations for uses other than landscape irrigation remain to be resolved.

North Carolina

North Carolina, like Florida, has a reasonable amount of yearly rainfall, amounting to more than 40 in. on average across the state. Over the past decade, the state has experienced significant extremes in weather, ranging from serious hurricanes that have reached as far inland as the middle of the state (Charlotte) to three exceptional droughts. Further exacerbating water resource issues in the state is that the major metropolitan areas of the state (with the exception of Charlotte) are all located at the top of three major river drainage basins. (These rivers feed the second- and third-largest estuaries in the United States.) For the most part, all available water resource sites are fully developed and interbasin transfer is not permitted, so reclaimed water becomes a more serious planning consideration for all communities.

To address this issue, before any community can obtain a permit to upgrade either a water plant or a wastewater plant or build a new facility, a study must be done to assess the feasibility of developing reclaimed water. This is an important administrative step that ensures that water reuse will be taken seriously as a water resource.

ABOUT THIS MANUAL

The remainder of this manual is divided into six chapters to highlight different aspects of water reclamation and the development of dual distribution systems.

Chapter 2, *Water Reuse Regulations and Guidelines*, looks at existing state regulations and guidelines with particular emphasis on treatment, reclaimed-water quality, and monitoring strategies to ensure high-quality reclaimed water.

Chapter 3, *Planning*, focuses on the planning concepts for the development of reclaimed-water and dual distribution systems. This covers not only the various sources of reclaimed water but also the various distribution system options and the coordination among utilities providing the source water and the distribution.

Chapter 4, *Engineering Design—Treatment*, examines all aspects of the issues associated with the design of treatment systems from source reliability to appropriate treatment technologies that may be employed to create reclaimed water for specific uses. Monitoring needs to ensure that the reclaimed water meets treatment objectives is also discussed.

Chapter 5, *Engineering Design—Distribution*, looks at the variety of design challenges associated with dual distribution systems, including demand management, hydraulic modeling, system components, storage, and safeguards.

Chapter 6, *Management*, highlights at least eight areas of management issues, ranging from general management philosophies and the protection of public health to understanding the customer base (marketing) and how to manage customer needs.

Chapter 7, *Financial/Economic Issues*, provides an overview of the issues associated with the economics of dual distribution, including an overall procedure for evaluating and proving the business case for the development of reclaimed water and its associated dual distribution system.

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Chapter **2**

Water Reuse Regulations and Guidelines

Reclaimed water has been successfully used for a wide range of nonpotable applications in the United States and is increasingly being adopted for indirect and direct potable uses. Although the use of reclaimed water for nonpotable purposes has been demonstrated to be safe in the United States, adverse health consequences associated with the reuse of raw or improperly treated wastewater are possible and well documented in the United States and other countries and has tainted the potential for reclaimed water. As a result, due diligence has effected water reuse standards and guidelines for nonpotable reuse that are directed principally at public health protection and based on the control of pathogenic organisms. Water quality considerations not associated with public health or environmental protection are seldom included in water reuse criteria by regulatory agencies. However, during development of water reuse regulations and guidelines, regulatory agencies do consider factors such as economics, technical feasibility, enforcement, public communication and notification, and political realities.

The United States Environmental Protection Agency (USEPA) has published Guidelines for Water Reuse (USEPA 2012) with contributions by the United States Agency for International Development (USAID), the Water Environment Federation (WEF), the International Water Association (IWA), The World Bank, the World Health Organization (WHO), the International Water Management Institute (IWMI), and consultants. In 2017, the USEPA released the Potable Reuse Compendium. This document supplements the 2012 Guidelines for Water Reuse and provides a current look at potable-water reuse practices, including direct potable reuse. The WHO developed Guidelines for the Safe Use of Wastewater, Excreta and Greywater in 2006 (updating a set of 1989 guidelines).

These guidelines are primarily directed toward the use of treated wastewater in agriculture. The WHO guidelines are generally much less stringent than regulations or guidelines adopted in various states within the United States.

The USEPA Guidelines for Water Reuse (2012) were developed to further the development of water reuse by serving as an authoritative reference on water reuse practices. The guidelines compile the state of experience in the design, operation, maintenance, management, finance, and regulation of water reuse in the United States. A more detailed description of this reference follows.

There are no federal regulations governing water reclamation and reuse in the United States. Currently, water reuse criteria are developed at the state level. Reclaimed-water standards vary considerably among states, although those with extensive reuse experience generally have comparable, conservative criteria or guidelines. Arguments for less restrictive standards are often predicated on a lack of documented health hazards rather than on any certainty that hazards are small or nonexistent. Some would argue that public health protection is predicated on proving the negative, which requires conservatism. In the absence of an understanding of basic public health protection principles and a common interpretation of scientific data, the selection of treatment processes and water quality limits is anticipated to continue to be somewhat subjective and inconsistent among the states.

Making reclaimed water suitable and safe for reuse applications is achieved by eliminating or reducing the concentrations of microbial and chemical constituents of concern through treatment and/or by limiting public or worker exposure to the reclaimed water via design and operational controls. Factors that affect the quality of reclaimed water include source water quality, reclaimed-water production (treatment) process effectiveness, process and product reliability, storage, and distribution system design and operation like the multiple barrier concepts of the Safe Drinking Water Act. Most states require implementation of industrial source control programs (e.g., pretreatment programs) to limit the input of chemical constituents that may adversely affect biological treatment processes and subsequent acceptability of the water for specific uses.

EXISTING STATE REGULATIONS

In the past, most state water reuse criteria were developed in response to a need to regulate a growing number of water reuse projects in the particular state. In recent years, some states that currently have few reuse projects have taken a proactive approach in response to drought conditions and lack of adequate community and municipal water supplies and have adopted water reuse criteria or guidelines, which tend to encourage implementation of projects. Some states (e.g., Arizona, California, Florida, and Texas) that have had criteria for many years have revised their water reuse regulations in recent years to address additional reclaimed-water uses, advances in wastewater treatment technology, and increased knowledge in the areas of microbiology and public health protection. These states (and others) have developed regulations for many types of nonpotable reclaimed-water applications.

Types of Reclaimed-Water Use

No states have regulations that cover all potential uses of reclaimed water, but several states have extensive regulations or standards that include criteria for a wide range of end uses of reclaimed water. Some states have regulations or guidelines directed at land treatment of wastewater effluent, emphasizing additional treatment or effluent disposal rather than intentional beneficial reuse, even though the effluent may result in irrigation of agricultural sites, golf courses, or public access lands. The absence of state criteria for

specific reuse applications does not necessarily prohibit those applications; many states evaluate specific uses on a case-by-case basis.

Reclaimed-water uses are generally defined as nonpotable and potable uses. As for any municipal or community water supply, the differentiation is that water produced for potable uses is suitable for human consumption, while nonpotable uses have no such limitations. Direct potable uses include human consumption, cooking and food preparation, and brushing teeth, while indirect potable uses include augmenting raw potable-water supplies by storage in an environmental buffer. Nonpotable uses include any other use: irrigation, industrial water, in-home use for toilet flushing, laundry, or cleaning and environmental enhancement.

General categories of nonpotable- and potable-water reuse applications are presented in Table 2-1.

Status of State Regulations and Guidelines

Table 2-2, adapted from the USEPA Guidelines for Water Reuse (USEPA 2012), summarizes the extent of current water reuse regulations and guidelines for nonpotable applications by state for different types of reuse. The table identifies those states that have regulations or guidelines and those that currently do not have either. Based on the data in Table 2-2, 22 states have adopted regulations regarding the use of reclaimed water, nine states have regulations where oversight of reuse is incidental to disposal regulations, 11 states have guidelines, and five states have guidelines where oversight of reuse is incidental to disposal regulations or design standards.

Whereas regulations are legally adopted and enforceable, guidelines and standards generally are advisory, voluntary, and non-enforceable. However, some states require through statute that published standards and guidelines be used in the design, operation, and permitting of water-reclamation projects. And in some cases, guidelines are incorporated in water reuse permits and thus become enforceable requirements. Some states prefer the use of guidelines to provide flexibility in regulatory requirements depending on project-specific conditions, which can result in

Table 2-1 Uses of reclaimed water

Category of Use	Specific Types of Use
Landscape irrigation	Parks, playgrounds, cemeteries, golf courses, roadway rights-of-way, school grounds, greenbelts, residential, and other lawns
Agricultural irrigation	Food crops, fodder crops, fiber crops, seed crops, nurseries, sod farms, silviculture, frost protection
Nonpotable urban uses (other than irrigation)	Toilet and urinal flushing, fire protection, air conditioner chiller water, vehicle washing, street cleaning, decorative fountains, and other water features
Impoundments	Ornamental, recreational
Environmental uses	Stream augmentation, marshes, wetlands, fisheries
Groundwater recharge	Aquifer storage and recovery, saltwater intrusion control, ground subsidence control
Indirect potable reuse (potable-water supply augmentation)	Groundwater recharge, surface water augmentation, reservoir storage
Direct potable reuse (potable-water supply)	Water supply directly into potable-water supply lines, potable-water treatment plants, and/or drinking water transmission or distribution systems
Industrial uses	Cooling, boiler feed, stack scrubbing, process water
Miscellaneous	Aquaculture, snowmaking, soil compaction, dust control, equipment washdown, livestock watering

Table 2-2 Summary of state reuse regulations and guidelines for reuse applications*

State	Regulations	Guidelines	No Regulations or Guidelines (1)	Change from 2004 Edition	Urban Reuse – Unrestricted	Urban Reuse – Restricted	Agricultural Reuse – Food Crops	Agricultural Reuse – Processed Food Crops and Non-Food Crops	Impoundments – Unrestricted	Impoundments – Restricted	Environmental Reuse	Industrial Reuse	Groundwater Recharge – Nonpotable Reuse	Indirect Potable Reuse
Alabama		☐				☐		☐						
Alaska	☐							☐						
Arizona	●			Update	●	●	●	●		●	●	●	●	●
Arkansas	☐			New (2)			☐							
California	●			Update	●	●	●	●	●	●		●	●	●
Colorado	●				●	●						●		
Commonwealth of the Northern Mariana Islands (CNMI)	☐			(3)		☐		☐						
Connecticut			—											
Delaware	●			Update	●	●	●	●	●	●		●	☐	
District of Columbia			—											
Florida	●			Update	●	●	●	●			●	●	●	●
Georgia		●		Update	●	●		●						
Guam				(4)										
Hawaii		●			●	●	●	●		●		●	●	●
Idaho	●			Update	●	●	●	●				●	●	
Illinois	●				●	●		●						
Indiana	☐			Update	☐	☐	☐	☐						
Iowa	●					●		●						
Kansas		☐			☐	☐	☐	☐				☐		
Kentucky			—											
Louisiana			—								●			
Maine			—											
Maryland		●		Update	●	●		●			●	●	●	
Massachusetts	●			New (2)	●	●	●	●	●	●	●	●	●	●
Michigan	☐						☐	☐						
Minnesota		●		(5)	●	●	●	●	☐			●		
Mississippi	☐					☐		☐				☐		
Missouri	●					●		●		☐	☐	☐		
Montana	●			Update (6)	●	●	●	●	●	●		●	●	
Nebraska	☐			Update	☐	☐	☐	☐	●	●		☐	●	
Nevada	●			Update	●	●		●		●	●	●		
New Hampshire			—											
New Jersey	●	●		New (7)	●	●	●	●				●		
New Mexico		●		Update (8)	●	●	●	●		●	●	●		
New York			—	(9)										
North Carolina	●			Update	●	●	●	●			●	●		*
North Dakota		●		Update	●	●		●	●		●	●	●	

(continued)

Table 2-2 Summary of state reuse regulations and guidelines for reuse applications* (continued)

State	Regulations	Guidelines	No Regulations or Guidelines (1)	Change from 2004 Edition	Urban Reuse – Unrestricted	Urban Reuse – Restricted	Agricultural Reuse – Food Crops	Agricultural Reuse – Processed Food Crops and Non-Food Crops	Impoundments – Unrestricted	Impoundments – Restricted	Environmental Reuse	Industrial Reuse	Groundwater Recharge – Nonpotable Reuse	Indirect Potable Reuse
Ohio		●			●	●		●						
Oklahoma	●			Update	●	●		●				●		
Oregon	●			Update (10)	●	●	●	●	●	●		●	●	
Pennsylvania		●			●	●	●	●	●	●	●	●		●
Rhode Island		●		New (11)	●	●		●				●		
South Carolina	●				●	●		●						
South Dakota		□		Update		□	□	□			□		□	
Tennessee		□		Update (12)	□	□		□	□	□	□	□		
Texas	●			Update	●	●	●	●	●	●	●	●		
Utah	●					●	●	●		●	●	●		●
Vermont	●					●		□						
Virginia	●			New (13)	●	●	●	●	●	●	●	●	□	●
Washington		●		Update (14)	●	●	●	●	●	●	●	●	●	●
West Virginia	□			(15)			□	□						
Wisconsin	□			Update			□	□				□	□	
Wyoming	●			Update	●	●	●	●				●		

Source: USEPA 2012

● The intent of the state's regulations or guidelines is oversight of water reuse.

□ The intent of the state's regulations or guidelines is oversight of disposal, and water reuse is considered incidental.

— The state does not have water reuse regulations or guidelines but may permit reuse on a case-by-case basis.

* No information is available at this time on regulations or guidelines on water reuse promulgated by federally recognized tribal nations, Puerto Rico, the US Virgin Islands, and American Samoa. In addition, the State of North Carolina passed legislation in 2014 to create indirect potable reuse requiring a mixture of 80% raw water and 20% reclaimed water in raw-water reservoirs.

(1) Specific regulations or guidelines on reuse not adopted; however, reuse may be approved on a case-by-case basis.

(2) The state had guidelines previously and now has adopted regulations.

(3) CNMI regulations were not listed in the 2004 guidelines.

(4) Guam has regulations pertaining to Urban Restricted Reuse and Indirect Potable Reuse, but they are not regulated by reuse or disposal regulations.

(5) Minnesota has been using the California rules as their Municipal Wastewater Reuse guidance since the mid-1990s. This was not reflected in the 2004 guidelines, which indicated that Minnesota had no guidance.

(6) Montana is in the midst of promulgating new reuse regulations, which are anticipated to be finalized by the time this manual is published.

(7) The state had guidelines previously and now has adopted reuse regulations as well as guidelines.

(8) Reclaimed-water projects in New Mexico are permitted under either a Ground Water Discharge Permit (which also controls use above ground) or a Construction Industries Permit if use in a building is included.

(9) Current interpretation is that New York has no regulations or guidelines.

(10) Groundwater recharge was added to Oregon's reuse regulations in 2008.

(11) The state had no guidelines or regulations previously and now has adopted guidelines.

(12) Tennessee was listed as having regulations in the 2004 guidelines; however, these were later deemed to be guidelines, not regulations.

(13) The state previously had no guidelines or regulations and has adopted regulations.

(14) Washington State currently has no regulations governing the use of reclaimed water. Draft regulations have been developed by the Department of Ecology in coordination with the Department of Health and formal rules advisory committee. The draft rules are incomplete. Adoption of the rules has been delayed until after June 30, 2013. The reclaimed-water use statute and formal standards, guidance, and procedures adopted in 1997 remain in effect.

(15) In the 2004 guidelines, West Virginia was listed as having regulations; however, these appear to be wastewater treatment regulations and do not specifically govern reuse.

differing requirements for similar uses within a state and lead to inequities in water reuse permits if guidelines are not uniformly applied. As reclaimed-water use becomes more pronounced in states having guidelines, most states eventually progress to development and imposition of regulations.

Specific applications within each type of reuse are listed in Table 2-3 and identified as follows:

- Unrestricted nonpotable urban uses—irrigation of parks, playgrounds, schoolyards, athletic fields, and residential property; toilet and urinal flushing, air conditioning, fire protection, construction, ornamental fountains, and reflecting pools
- Restricted nonpotable urban uses—golf courses, cemeteries, highway medians, and similar areas
- Agricultural irrigation of food crops—irrigation of food crops intended for human consumption; this category is often further classified as to whether the food crop is to be processed or consumed raw and whether there is direct contact between the reclaimed water and the edible portion of the crop
- Agricultural irrigation of nonfood crops—irrigation of fodder, fiber and seed crops, pastureland, commercial nurseries, and sod farms
- Unrestricted recreational impoundment—an impoundment of water for which no limitations are imposed on body-contact water recreation activities
- Restricted recreational impoundment—an impoundment of reclaimed water for which recreation is limited to fishing, boating, and other noncontact recreational activities where only incidental contact with reclaimed water occurs
- Environmental uses—creation of artificial wetlands, enhancement of natural wetlands, and sustainment of stream flows
- Industrial uses—cooling-system makeup, boiler feedwater, process water, and general washdown
- Potable reuse—supplementing or replacing raw drinking water sources with reclaimed water through introduction to the raw water supply (e.g., reservoir or aquifer system) or directly into the intake of a drinking water treatment plant

Regulatory Structures

“Regulations are essential for public peace and order, for health and safety and for our mutual convenience...there are too many of us living too close together to manage without them” (Sparrow 2000). And even when regulations are necessary, “we do not need regulators who are nitpicky, unreasonable, unnecessarily adversarial, rigidly bureaucratic and incapable of applying discretion” (Sparrow 2000).

Regulations are governments’ way of implementing public policies. They interpret the policies legislative bodies write into law in a way that society can understand and implement in real life. The best way to ensure success for the regulated community and consumers is to ensure that the rules that regulators must apply are developed from the proper perspective. The fundamental approach to the regulations will determine whether they are punitive and overly limiting or are flexible and encourage success.

For much of the past, reclaimed water was seen as an alternative to wastewater treatment and disposal, a way of preventing wastewater from reaching a natural water supply and meeting discharge limits. Today, as noted in Chapter 1, drought, population growth, and limitations to natural water supplies have changed the primary driver from environmental protection to providing an adequate community water resource portfolio. New regulatory programs need to keep up with this change.

Table 2-3 Number of states with regulations or guidelines for each type of nonpotable-water reuse

Category of Reuse		Description ¹	Number of States or Territories With Rules, Regulations, or Guidelines Addressing Reuse
Urban Reuse	Unrestricted	The use of reclaimed water for nonpotable applications in municipal settings where public access is not restricted	32
	Restricted	The use of reclaimed water for nonpotable applications in municipal settings where public access is controlled or restricted by physical or institutional barriers, such as fencing, advisory signage, or temporal access restriction	40
Agricultural Reuse	Food Crops	The use of reclaimed water to irrigate food crops that are intended for human consumption	27
	Processed Food Crops and Non-food Crops	The use of reclaimed water to irrigate crops that are either processed before human consumption or not consumed by humans	43
Impoundments	Unrestricted	The use of reclaimed water in an impoundment in which no limitations are imposed on body-contact water recreation activities (some states categorize snowmaking in this category)	13
	Restricted	The use of reclaimed water in an impoundment where body contact is restricted (some states include fishing and boating in this category)	17
Environmental Reuse		The use of reclaimed water to create, enhance, sustain, or augment water bodies, including wetlands, aquatic habitats, or stream flow	17
Industrial Reuse		The use of reclaimed water in industrial applications and facilities, power production, and extraction of fossil fuels	31
Groundwater Recharge – Nonpotable Reuse		The use of reclaimed water to recharge aquifers that are not used as a potable-water source	16
Potable Reuse	Indirect Potable Reuse (IPR)	Augmentation of a drinking water source (surface or groundwater) with reclaimed water followed by an environmental buffer that precedes normal drinking water treatment	10 ²
	Direct Potable Reuse (DPR)	The introduction of reclaimed water (with or without retention in an engineered storage buffer) directly into a water treatment plant, either collocated or remote from the advanced wastewater treatment system	0

Source: USEPA 2012

¹ These definitions, written in the 2010–2011 period, do not reflect the refinements in the definitions developed over the last several years. See updated definitions on pages 1 and 2.² Updated to reflect North Carolina regulations effective in 2014.

Currently, the basic regulatory approach used by nearly all states, whether they implement regulations, standards, or guidelines, relies on the concept of wastewater discharge permitting through the issuance of a “permit.” This concept relies on the regulatory authority to provide “permission” to produce, distribute, and use reclaimed water. This concept places the regulatory authority in the ultimate position to determine the concepts under which a water-reclamation plant is planned, designed, constructed, and operated and narrowly defines the product quality and quantity with precise limits, all of which are included in a formal “permit.”

This model works well for its intended use: the control of the discharge or pollutants or contaminants into the natural environment. The regulatory authority has the duty to protect the quality of the environment for future generations. This process is well developed and allows the regulatory authority to predetermine the level of pollution that the local environment can sustain without irreparable harm.

However, increasing pressures from drought and population growth have put increasing demands on the amount of water available to adequately supply communities. Reclaimed water is becoming the best and most readily available new or augmented resource for communities. Reclaimed water has evolved from an alternative to keeping wastewater from being discharged to the environment and has become the solution to a lack of supply for nonpotable- and now even potable-water demands. This evolution requires a more flexible and intended application-based approach to developing a water-reclamation project.

New regulatory structures need to consider implementing the concepts of the Safe Drinking Water Act for safe and adequate water supplies in lieu of Clean Water Act wastewater disposal. This approach does not require that a community seek the permission of a regulatory authority to meet its fundamental responsibility to provide adequate water supply. Drinking water regulatory programs set the expectation that communities provide their customers with high-quality, highly reliable water supplies. This is accomplished by licensing local water suppliers in lieu of state regulatory authorities to develop and construct production facilities and deliver high-quality water to customers for intended uses through conformance with established public health-based water quality and quantity standards through ensuring conformance with minimum design standards and product water monitoring and reporting.

This new approach may require a change in statutory authority for almost every state. Considering the increasing water supply pressures, states might begin considering this fundamental change in water supply regulatory responsibility.

TREATMENT, QUALITY, AND MONITORING EQUIPMENT

Treatment and Quality Requirements

Regulations, standards, and guidelines commonly include requirements addressing water quality, monitoring, treatment processes, treatment process and product quality reliability, operation and maintenance, use area controls, cross-connection control, and permitting. Most state water reuse regulations specify both reclaimed-water quality limits and treatment process requirements, although a few states, such as Texas and New Mexico, do not prescribe treatment processes and rely solely on final product water quality limits. The most common parameters for which water quality limits are imposed are biochemical oxygen demand (BOD), turbidity or total suspended solids (TSS), total or fecal coliform bacteria, and chlorine contact time and residual.

Treatment process requirements are applied to establish water quality like the “treatment techniques” used by the Safe Drinking Water Act, Surface Water Treatment Rule.

Final product water quality is set through designating treatment process operational limits that will ensure: (a) minimum contaminant removals or (b) maximum product water quality concentrations. These product water quality parameters are maintained through monitoring the treatment process consistency.

Most state regulations include two or more “classes” of reclaimed-water requirements, which become increasingly more restrictive as the potential for direct or indirect human contact with reclaimed water increases. Low-quality reclaimed water (e.g., secondary treatment with no or minimal disinfection) is acceptable in some states for uses where there is no human contact with the water, such as irrigation of pasture for nondairy animals or irrigation of seed crops not intended for human consumption. In many states, the definition of secondary treatment requires that neither the BOD nor TSS exceeds 30 mg/L. Daily sampling for BOD and TSS using composite samples is usually required, although less frequent sampling is allowed in some states. A few states use the term *oxidized wastewater* to define secondary treated wastewater, where oxidized wastewater is defined as wastewater in which the organic matter has been stabilized, is imputrescible, and contains dissolved oxygen. Most state regulations do not require a specific type of secondary treatment (e.g., conventional activated sludge, extended aeration activated sludge, lagoon systems, and other types of secondary treatment) for effluent to be acceptable for reuse.

For uses such as restricted-access irrigation sites where human contact with reclaimed water is unlikely but may occur incidentally, a higher level of treatment (e.g., secondary treatment with a moderate level of disinfection that is not sufficient to destroy all pathogens) is typically required, although some states require relatively high levels of disinfection for uses of this type. The most stringent treatment and quality requirements for nonpotable uses apply to reclaimed water used for the irrigation of food crops eaten raw, unrestricted access landscape irrigation, and other nonpotable urban reuse applications such as toilet and urinal flushing, fire protection, vehicle washing, and similar uses where either direct or indirect contact with the water is expected. For these uses, most states take a conservative approach and require secondary treatment, filtration (chemical coagulation may be required prior to filtration), and a high level of disinfection (e.g., 2.2 total coli/100 mL or no detectable fecal coli/100 mL) to eliminate pathogenic organisms or reduce them to insignificant levels in the reclaimed water.

In most states that have definitive water reuse criteria, alternative treatment methods or treatment techniques may be acceptable if they can be demonstrated to be as effective and reliable as those prescribed in the regulations (Crook 1998). For example, although most state regulations are based on using chlorine for disinfection, UV radiation that reliably achieves the required level of disinfection generally is acceptable. Similarly, membrane treatment such as microfiltration is an effective alternative to conventional media filtration.

There is a great deal of variation in treatment and quality requirements in selected state regulations for several nonpotable applications of reclaimed water. Similar variations among criteria occur for other uses of reclaimed water. A detailed summary of all state water reuse regulations or guidelines as of 2012 is included in the USEPA *Guidelines for Water Reuse*, Tables 4-7 to 4-16, which are included as an appendix to this manual.

Treatment and quality standards and guidance currently proposed for the production of potable reclaimed water are often much more stringent than those imposed for nonpotable uses. Additional treatment commonly includes multiple levels of membrane treatment and advanced oxidation processes to address chemical constituents of concern when consumed.

Monitoring Requirements

Decisions involving monitoring include selection of water quality parameters, numerical limits, sampling frequency, treatment process efficiency tracking, and the monitoring compliance point.

Chemical constituents. With a few exceptions, there appear to be minimal health risks associated with chemical constituents where reclaimed water is used for nonpotable applications; therefore, reclaimed-water requirements typically focus on microbial health risks. While many industrial uses require water of higher quality than that typically present in reclaimed water, water reuse regulations are intended to provide health protection and only include requirements to attain that end. Some industrial uses of reclaimed water, such as incorporating reclaimed water into food or drink products, are prohibited.

Effects of physical parameters (e.g., pH, color, temperature, and particulate matter) and chemical constituents (e.g., chlorides, sodium, and heavy metals) are well known, and recommended limits have been established for many constituents (Water Pollution Control Federation 1989, Westcot and Ayers 1985, USEPA 1981, National Academy of Sciences–National Academy of Engineering 1973). While there has been some concern regarding irrigation of food crops with reclaimed water, available data indicate that potentially toxic organic constituents do not enter edible portions of plants (National Research Council 1996), and reuse regulations do not include limits for pesticides or other trace organic contaminants.

However, due to pressure for potable reuse, chemical and physical constituent limits can be important to final water quality. In general, water quality must conform with all the maximum contaminant levels set by the Safe Drinking Water Act for primary and secondary contaminants. Additional monitoring and conformance with state-established advisory contaminant levels can be established for unregulated contaminants that are suspected of human health risk. In addition, the state of California is in the process of establishing health criteria and limits for contaminants such as pesticides, pharmaceuticals, and personal-care product residuals. Currently, there are no universally set standards or monitoring requirement for this class of contaminants.

Organic matter. Some of the adverse effects associated with organic substances are that they are aesthetically displeasing (may be malodorous, impart color, and create unsightly deposits), provide food for microorganisms, adversely affect disinfection processes, and consume oxygen. BOD limits are intended to demonstrate that the organic matter has been stabilized via treatment, is non-putrescible, and has been lowered to levels commensurate with anticipated types of reuse. The compliance point for BOD typically is after secondary treatment or after the final treatment process (i.e., in the product water as it leaves the treatment facility).

Particulate matter. The removal of suspended matter is related to health protection. It is known that particulate matter can shield microbes from disinfectants. Organic matter consumes chlorine, resulting in less of the disinfectant being available for destruction or inactivation of microbial pathogens. Although reclaimed-water monitoring requirements for particulate matter vary from state to state, there is general agreement that where a high level of disinfection is required, particulate matter should be reduced to low levels, e.g., 2 nephelometric turbidity units (NTU) or 5 mg/L TSS, prior to disinfection to ensure reliable destruction or inactivation of microbial pathogens.

Suspended solids measurements are typically performed daily on a 24-hour composite sample and produce an average value for the sampling period. Monitoring for total suspended solids is appropriate for reclaimed water that receives only secondary treatment because the effluent is not intended to be completely free of measurable levels of all pathogens. However, for high-level nonpotable uses of reclaimed water where contact, ingestion, or inhalation is likely, continuously monitored turbidity is superior to daily

suspended solids measurements as an aid to treatment performance. Where turbidity monitoring is required, most states require that turbidity be continuously monitored.

California specifies different turbidity requirements depending on type of treatment. Where media filtration is the added treatment process, turbidity after filtration cannot exceed an average of 2 NTU within any 24-hour period, cannot exceed 5 NTU more than 5 percent of the time within a 24-hour period, and cannot exceed 10 NTU at any time. Where membranes are used in lieu of media filtration, turbidity cannot exceed 0.2 NTU more than 5 percent of the time within a 24-hour period and cannot exceed 0.5 NTU at any time. This turbidity requirement is based on observed turbidity levels in product water from properly designed and operated microfiltration unit processes having a nominal pore size in the 0.1-mm range and reflects attainability and good engineering practice (Crook 2002).

Low turbidity or suspended solids values alone do not indicate that reclaimed water is devoid of microorganisms. As such, turbidity or TSS measurements are not used as an indicator of microbiological quality but rather as an indication of failure of membrane integrity, which affects final reclaimed-water disinfection requirements.

Microbial indicator organisms. It is impractical to monitor reclaimed water for all pathogenic organisms of concern, and surrogate parameters are universally accepted. In the United States, either total or fecal coliform organisms are the preferred indicator organisms for reclaimed water. Other indicator organisms (e.g., *enterococci*, *E. coli*, *Clostridium perfringens*, and coliphages) have been proposed but have not gained wide acceptance. Coliform samples are usually required to be collected daily during peak flow conditions to represent the most demanding treatment facility operating conditions. Regulatory compliance varies in different states but usually is based on median or geometric mean values over a given time period. While high levels of coliforms are indicative of fecal contamination, the absence of coliform organisms alone is not an adequate indicator that the water is uncontaminated.

The total coliform analysis includes enumeration of organisms of both fecal and nonfecal origin, while the fecal coliform analysis is specific for coliform organisms of fecal origin. Therefore, fecal coliforms are better indicators of fecal contamination than total coliforms. Regulatory decisions regarding the selection of which coliform group to use are somewhat subjective. There is no consensus among microbiologists that the total coliform analysis is superior to the fecal coliform analysis. The use of total coliforms provides an added safety factor that appeals to regulatory agencies that adhere to a conservative approach to water reuse.

Water reuse regulations do not include specific limits for parasitic or viral pathogens. Parasites have not been shown to present a health problem at water reuse operations in the United States, although there has been considerable interest in recent years regarding the occurrence and significance of *Giardia* and *Cryptosporidium* in reclaimed water. Monitoring for such organisms is required in some states. For example, Florida requires monitoring of *Giardia* and *Cryptosporidium* with sampling frequency based on treatment plant capacity (Florida Department of Environmental Protection 1999). In consideration of the likelihood of ingesting reclaimed water while swimming in nonrestricted recreational impoundments and the paucity of information regarding parasite removal where a discrete chemical clarification process is omitted from the treatment train, the California regulations require that reclaimed water used for nonrestricted recreational impoundments be monitored for enteric viruses, *Giardia*, and *Cryptosporidium* during the first two years of operation if the treatment chain does not include a chemical clarification unit process between the coagulation and filtration processes (State of California 2015).

Viruses are of concern in reclaimed water, but virus limits are not included in regulations for a variety of reasons, including the fact that viruses can be reduced or inactivated to low or immeasurable levels via appropriate wastewater treatment that includes secondary treatment, chemical coagulation, filtration, and a high level of

disinfection (Yanko 1993, Crook 1989, Engineering-Science 1987, Sanitation Districts of Los Angeles County 1977). However, California is using viruses for performance verification where CT and UV doses are based on virus inactivation. This subject is being further studied in California and under consideration in other states such as North Carolina.

As analytical detection and identification techniques have improved, it has become apparent that coliforms, by themselves, are inadequate indicators of the presence or concentration of some pathogens, particularly viruses and parasites, as many pathogens have been shown to be more resistant to wastewater treatment than classical microbial indicators such as coliforms. In addition, concerns for pathogenic organisms such as *Giardia* and *Cryptosporidium*, which may originate from nonhuman sources, have led to questioning the use of indicators that arise primarily from human fecal inputs. Therefore, it is improper to infer that a high level of either total or fecal coliform removal alone is indicative of high levels of pathogen removal from reclaimed water.

However, regardless of the effectiveness or appropriateness of current microbial monitoring approaches, total coliform and fecal coliform are well-established indicators of consistency in reclaimed-water treatment. Based on many decades of experience with these tests and results, they remain valuable indicators of overall treatment process quality when used in addition to other indicators such as turbidity and disinfection system output.

Disinfection. Where chlorine is used as the disinfectant, many states require continuous monitoring of chlorine residual and specify both the chlorine residual and contact time that must be met, particularly for reclaimed-water uses where contact with the water is likely to occur. Required theoretical disinfection contact times differ substantially from state to state and range from 15 minutes to 2 hours at peak flow.

While the need to maintain a chlorine residual in reclaimed-water distribution systems to prevent odors, slimes, and bacterial regrowth was recognized early in the development of dual water systems (Okun 1979), only in the late 1990s did regulatory agencies begin to require such residuals. Several states now require maintenance of a chlorine residual in distribution systems carrying reclaimed water. The USEPA *Guidelines for Water Reuse* recommend that a chlorine residual of at least 0.5 mg/L be maintained in reclaimed-water distribution lines.

The use of ultraviolet (UV) irradiation for disinfection is becoming more prevalent at water-reclamation facilities. Because UV does not leave a residual in water, it is advantageous to add a low dose of chlorine to the reclaimed water as it enters the distribution system. Where UV is used for disinfection, many states do not specify UV dosage or design or operating conditions, although some state regulations require compliance with the Ultraviolet Disinfection Guidelines for Drinking Water and Water Reuse (NWRI 2012). These comprehensive guidelines address UV dose, reactor design, reliability, monitoring and alarms, field commissioning testing, performance monitoring, and elements of an engineering report. The guidelines recommend, for example, a design UV dose of 100 mJ/cm² to reliably achieve a total coliform level of ≤ 2.2 total coli/100 mL and 5-log inactivation of seeded poliovirus in tertiary treated reclaimed water.

Monitoring compliance point. Because particulate matter has a direct influence on disinfection effectiveness, turbidity and TSS limits usually are required to be met in the wastewater immediately after filtration. The location of the monitoring point for indicator organism regulatory compliance has been an issue in some states. One viewpoint is that the reclaimed water should meet all water quality requirements at the point of use. Arguments in favor of this position generally center on the possible regrowth of microorganisms between the treatment plant and the point of reuse. However, restrictive coliform requirements, in conjunction with water quality and treatment process requirements, ensure that pathogenic bacteria are destroyed during disinfection and any bacterial regrowth would only be that of nonpathogenic coliform organisms. Viruses require living cells to invade and replicate themselves and do not increase in concentration in the open

environment. Similarly, parasitic cysts and oocysts do not replicate in water. Although water quality degradation in distribution systems is well known, water quality monitoring at the point of use is not universally required. But this should not imply that water quality control after treatment should be ignored. In most states, the monitoring compliance point for indicator organisms is immediately after disinfection.

Groundwater monitoring programs associated with irrigation of reclaimed water are required in several states. In general, groundwater monitoring programs require that at least one well be located hydraulically upgradient of the irrigation site to assess background groundwater quality within the aquifer and one or more wells be located hydraulically downgradient of the reuse site to monitor compliance. Sampling parameters, limits, and frequency of sampling vary among states that require such monitoring.

Treatment Process and Product Reliability

Water-reclamation facilities are expected to operate at capacity full-time and year-round and always produce high-quality, safe reclaimed water. This is accomplished through the concept of reliability. Reliability is defined as the ability of the facility or a component to perform the required function for the required time frame. Reliability is based on the concept that it is impossible to be fail-safe, but it is possible to fail safely. Product reliability from production through delivery is the cornerstone of public health protection with the use of reclaimed water. Unfortunately, not all states have adopted regulations, standards, or guidelines to ensure that reclaimed water meets appropriate standards as it enters the distribution system and at the point of use.

Reliability measures include alarm systems that warn of power failure or failure of essential unit processes, automatic standby power supplies, multiple or standby treatment process units, emergency storage or disposal of inadequately treated wastewater, elimination of treatment process bypassing, monitoring devices and automatic controllers, and flexibility of design. Some states require adherence to USEPA's Class I reliability requirements (USEPA 1974), which include many of the measures previously described.

Several states include reliability in their regulations, standards, and guidelines by requiring filtration of reclaimed water when human contact with the water is likely. Water reuse regulations in some of these states require that chemical addition facilities be installed prior to the filtration unit process, although the chemical addition facilities may remain idle unless turbidity or TSS limits cannot be met after filtration.

To ensure that the water-reclamation facility product meets all requirements, a formal reliability assessment should be conducted. A reliability assessment is a determination and review of the reliability of the processes and equipment components of the entire reclaimed-water system from production through storage and distribution and must include a report of the review of operating standards, maintainability, critical operating conditions, spare parts requirements and availability, and any other issue(s) that affect the performance of the reclamation facility. Reliability assessments should begin during facility planning stages and be an integral part of the facility design.

Use Area Controls

There is little consistency on use area controls specified in state regulations. Commonly specified use area controls include the following: color-coding reclaimed-water pipelines and appurtenances; cross-connection control provisions; signage; setback distances between reclaimed-water use areas and various sites such as potable-water supply wells, property lines, residential areas, and roadways; confinement of reclaimed water to the designated use area; protection of drinking water fountains against reclaimed-water spray;

and prohibition of hose bibs on reclaimed-water irrigation systems. Use area controls are discussed in Chapter 4.

Setback distances. The intent of setback distances, which are sometimes called buffer zones, is to prevent excessive human contact with the reclaimed water or to prevent potential contamination of potable-water supply sources. Although predictive models have been developed to estimate microorganism concentrations in aerosols or larger water droplets resulting from spray irrigation of wastewater, setback distances are somewhat arbitrarily determined by regulatory agencies based on experience and judgment.

Many states have established setback distances between reclaimed-water use areas and surface waters, potable-water supply wells, or areas accessible to the public. Setbacks are usually required where reclaimed water is used for spray irrigation, cooling water in towers, and other uses where spray or mist is formed. Setbacks may also be required at irrigation or impoundment sites to prevent percolated reclaimed water from reaching potable-water supply wells or surface waters. Setback distances vary depending on the quality of reclaimed water, type of reuse, method of application, and purpose of the setback (e.g., to avoid human contact with the water or protect potable-water sources from contamination). Setback distances, where required, vary considerably from state to state, and range from 15 m (50 ft) to as much as 240 m (800 ft). Some states do not require setback distances from irrigated areas to areas accessible to the public if a tertiary treatment and a high level of disinfection are provided.

Cross-connection control. States with comprehensive water reuse criteria typically include cross-connection control regulations to prevent interconnecting reclaimed-water and potable-water pipelines. Regulations often address identification of transmission and distribution lines and appurtenances via color-coding, taping, or other means; pipeline separation; allowable pressures; surveillance; and backflow-prevention devices (see Chapter 5). At use areas that receive both potable and reclaimed water, backflow-prevention devices are almost always required on the potable-water supply line to each site to reduce the potential of contaminating the potable drinking water system in the event of a cross-connection at a use area. Direct connections between reclaimed-water and potable-water lines are not allowed in any state.

Some states allow the use of reclaimed water for toilet and urinal flush water in buildings where residents or other unauthorized personnel do not have access to the plumbing system for repairs or modifications. The use of reclaimed water in single-family residential buildings is generally prohibited. Reclaimed water used inside buildings for toilet and urinal flushing or for fire protection presents special cross-connection control concerns. Although such uses do not result in frequent human contact with the water, regulatory agencies usually require that the reclaimed water be essentially pathogen free to reduce health hazards upon inadvertent cross-connection to potable-water systems.

California's Water Recycling Criteria (State of California 2015) require compliance with the California State Water Resources Control Board, Division of Drinking Water (DDW) cross-connection control regulations (California State Water Resources Control Board 2017), which address the use of reclaimed water. They require that water systems serving residential property through a dual water system that uses reclaimed water for landscape irrigation must, at a minimum, be protected by a double-check-valve-assembly backflow preventer. The same requirement applies to a public water system in buildings using reclaimed water in a separate piping system within buildings for fire protection. A reduced pressure principle backflow-prevention device is required at a minimum to protect the potable system at sites other than those previously mentioned. An air gap separation is required where a public water system is used to supplement a reclaimed-water supply. The California Plumbing Code similarly addresses cross-connection concerns (IAPMO 2016). California's recycled water criteria for dual plumbed systems within buildings include the following requirements:

- prohibition of internal use of reclaimed water within any individually owned residential unit, including multiplexes or condominiums;
- submission of a report to DDW that includes a detailed description of the intended use area, plans and specifications, and cross-connection control provisions and testing procedures;
- testing of all backflow preventers annually;
- notification of any incidence of backflow from the reclaimed-water system into the potable-water system within 24 hours of discovery;
- conformance to the DDW cross-connection control regulations; and
- the use of reclaimed water internally only for fire suppression systems by facilities that produce or process food products or beverages.

Water User Agreements

Many reclaimed-water purveyors require reclaimed-water users to sign agreements that establish the terms and conditions under which the reclaimed water may be used. This helps ensure that regulatory requirements are met. These formal agreements are between the water customer and the purveyor. Content of such agreements typically include the following.

- Declaration of the place of use and storage. This often includes identification of intended use.
- Prohibition of resale or conveyance to locations other than the agreed-upon place of use. In the case of bulk reclaimed water, the agreement often includes restrictions on mode of transport and further point-of-delivery restrictions.
- Specific restrictions on use.
- Metering requirements.
- Rate schedule with acknowledgment that rates are subject to change.
- Compliance with regulations.
- Required system identification. This may include signage as well as the requirement for purple pipe on privately owned portions of the distribution system.
- Backflow prevention requirements.
- Conformance with the Uniform Plumbing Code, where applicable.
- Acceptance of inspection and compliance with permitting requirements.
- Notice of potential disruption of service.
- Notice of requirements related to transfer or lease of property.
- Notice of termination of service if terms of the agreement are not maintained.
- Indemnification clause.

Storage Requirements

Storage requirements for dedicated reuse facilities vary from state to state and are dependent on geographic location, climate, and site conditions. A minimum storage volume equal to three days of the average design flow is typical in water-short states with warm climates, while more than 200 days of storage are required in some northern states because of the high number of nonirrigation days resulting from high rainfall or freezing temperatures. Many of the states that have storage requirements in their regulations

or guidelines require that a water balance be performed on the water reuse system, considering all inputs and outputs of water to the system.

Some states put end users on notice that supply may be intermittent. Some states require end users to provide initial estimates of intended reclaimed-water use quantities at the time of application to help in planning related to meeting demand.

US Environmental Protection Agency Guidelines

The USEPA, in conjunction with the US Agency for International Development, published *Guidelines for Water Reuse* in 1992 (USEPA 1992). The guidelines were updated in 2004 (USEPA 2004) and again in 2012 (USEPA 2012) to address technological advances, research data, and other information generated in the last two decades. In 2017, the EPA released the Potable Reuse Compendium to supplement the 2012 Guidelines for Water Reuse to provide a current look at potable-water reuse practices, including direct potable reuse (USEPA 2017). The primary purpose of the document is to provide guidelines, with supporting information, for utilities and regulatory agencies in the United States, particularly in states where standards do not exist or are being revised or expanded. The guidelines address various aspects of water reuse and include recommended treatment processes, reclaimed-water quality limits, monitoring frequencies, setback distances, and other controls for various water reuse applications. A summary of the guidelines for nonpotable reclaimed-water applications is presented in Table 2-4.

Both reclaimed-water quality limits and wastewater treatment unit processes are recommended for the following reasons: water quality criteria involving surrogate parameters alone do not adequately characterize reclaimed-water quality; a combination of treatment and quality requirements known to produce reclaimed water of acceptable quality obviates the need to monitor the finished water for certain constituents; expensive, time-consuming, and in some cases, questionable monitoring for pathogenic microorganisms is eliminated without compromising health protection; and treatment reliability is enhanced.

The guidelines recommend that, regardless of the type of reclaimed-water use, some level of disinfection should be provided to avoid adverse health consequences from inadvertent contact or accidental or intentional misuse of a water reuse system. For nonpotable uses of reclaimed water, two different levels of disinfection are recommended. Reclaimed water used for applications where no direct public or worker contact with the water is expected should be disinfected to achieve a fecal coliform concentration not exceeding 200/100 mL for the following reasons: most bacterial pathogens will be destroyed or reduced to low or insignificant levels in the water; the concentration of viable viruses will be reduced somewhat; disinfection of secondary effluent to this coliform level is readily achievable at minimal cost; and significant health-related benefits associated with disinfection to lower, but not pathogen-free, levels are not obvious.

For uses where direct or indirect contact with reclaimed water is likely or expected, and for dual water systems where there is a potential for cross-connections with potable water lines, the guidelines recommend a high level of disinfection to produce reclaimed water having no detectable fecal coliform organisms/100 mL. This more restrictive disinfection level is intended for use in conjunction with tertiary treatment and other water quality limits, such as a turbidity of 2 NTU in the wastewater prior to disinfection. This combination of treatment and water quality limits has been shown to produce reclaimed water that is essentially free of measurable levels of bacterial and viral pathogens.

Table 2-4 USEPA suggested guidelines for nonpotable reuse of municipal wastewater¹

Reuse Category and Descriptions	Treatment	Reclaimed Water Quality ²	Reclaimed Water Monitoring	Setback Distances ³	Comments
Urban Reuse					
Unrestricted The use of reclaimed water in nonpotable applications in municipal settings where public access is not restricted	- Secondary⁴ - Filtration⁵ - Disinfection⁶	- pH = 6.0–9.0 ≤10 mg/L BOD⁷ ≤2 NTU⁸ - No detectable fecal coliform/100 mL^{9,10} 1 mg/L Cl₂ residual (min.)¹¹	- pH – weekly - BOD – weekly - Turbidity – continuous - Fecal coliform – daily - Cl₂ residual – continuous	50 ft (15 m) to potable-water supply wells; increased to 100 ft (30 m) when located in porous media¹⁸	- At controlled-access irrigation sites where design and operational measures significantly reduce the potential of public contact with reclaimed water, a lower level of treatment (e.g., secondary treatment and disinfection) to achieve <14 fecal coliform/100 mL may be appropriate. - Chemical (coagulant and/or polymer) addition prior to filtration may be necessary to meet water quality recommendations. - The reclaimed water should not contain measurable levels of pathogens.¹² - Reclaimed water should be clear and odorless. - Higher chlorine residual and/or a longer contact time may be necessary to assure that viruses and parasites are inactivated or destroyed. - Chlorine residual >0.5 mg/L in the distribution system is recommended to reduce odors, slime, and bacterial regrowth. - See Section 3.4.3 in the 2004 guidelines for recommended treatment reliability requirements.
Restricted The use of reclaimed water in nonpotable applications in municipal settings where public access is controlled or restricted by physical or institutional barriers, such as fencing, advisory signage, or temporal access restriction	- Secondary⁴ - Disinfection⁶	- pH = 6.0–9.0 ≤30 mg/L BOD⁷ ≤30 mg/L TSS ≤200 fecal coliform/100 mL^{9,13,14} 1 mg/L Cl₂ residual (min.)¹¹	- pH – weekly - BOD – weekly - TSS – daily - Fecal coliform – daily - Cl₂ residual – continuous	300 ft (90 m) to potable-water supply wells 100 ft (30 m) to areas accessible to the public (if spray irrigation)	- If spray irrigation, TSS less than 30 mg/L may be necessary to avoid clogging of sprinkler heads. - See Section 3.4.3 in the 2004 guidelines for recommended treatment reliability requirements. - For use in construction activities including soil compaction, dust control, washing aggregate, making concrete; worker contact with reclaimed water should be minimized and a higher level of disinfection (e.g., <14 fecal coli/100 mL) should be provided when frequent worker contact with reclaimed water is likely.

(continued)

Table 2-4 USEPA suggested guidelines for nonpotable reuse of municipal wastewater¹ (continued)

Reuse Category and Descriptions	Treatment	Reclaimed Water Quality ²	Reclaimed Water Monitoring	Setback Distances ³	Comments
Agricultural Reuse					
Food Crops¹⁵ The use of reclaimed water for surface or spray irrigation of food crops which are intended for human consumption, consumed raw	- Secondary⁴ - Filtration⁵ - Disinfection⁶	- pH = 6.0–9.0 ≤10 mg/L BOD⁷ ≤2 NTU⁸ - No detectable fecal coliform/100 mL^{9,10} 1 mg/L Cl₂ residual (min.)¹¹	- pH – weekly - BOD – weekly - Turbidity – continuous - Fecal coliform – daily - Cl₂ residual – continuous	50 ft (15 m) to potable-water supply wells; increased to 100 ft (30 m) when located in porous media¹⁸	- See Table 3-5 of the 2012 USEPA Guidelines for Water Reuse for other recommended chemical constituent limits for irrigation. - Chemical (coagulant and/or polymer) addition prior to filtration may be necessary to meet water quality recommendations. - The reclaimed water should not contain measurable levels of pathogens.¹² - Higher chlorine residual and/or a longer contact time may be necessary to assure that viruses and parasites are inactivated or destroyed. - High nutrient levels may adversely affect some crops during certain growth stages. - See Section 3.4.3 in the 2004 guidelines for recommended treatment reliability requirements.
Processed Food Crops¹⁵ The use of reclaimed water for surface irrigation of food crops which are intended for human consumption, commercially processed Non-Food Crops The use of reclaimed water for irrigation of crops which are not consumed by humans, including fodder, fiber, and seed crops, or to irrigate pasture land, commercial nurseries, and sod farms	- Secondary⁴ - Disinfection⁶	- pH = 6.0–9.0 ≤30 mg/L BOD⁷ ≤30 mg/L TSS ≤200 fecal coliform/100 mL^{9,13,14} 1 mg/L Cl₂ residual (min.)¹¹	- pH – weekly - BOD – weekly - TSS – daily - Fecal coliform – daily - Cl₂ residual – continuous	300 ft (90 m) to potable-water supply wells 100 ft (30 m) to areas accessible to the public (if spray irrigation)	- See Table 3-5 of the 2012 USEPA Guidelines for Water Reuse for other recommended chemical constituent limits for irrigation. - If spray irrigation, TSS less than 30 mg/L may be necessary to avoid clogging of sprinkler heads. - High nutrient levels may adversely affect some crops during certain growth stages. - See Section 3.4.3 in the 2004 guidelines for recommended treatment reliability requirements. - Milking animals should be prohibited from grazing for 15 days after irrigation ceases. A higher level of disinfection (e.g., to achieve <14 fecal coliform/100 mL) should be provided if this waiting period is not adhered to.

(continued)

Table 2-4 USEPA suggested guidelines for nonpotable reuse of municipal wastewater¹ (continued)

Reuse Category and Descriptions	Treatment	Reclaimed Water Quality ²	Reclaimed Water Monitoring	Setback Distances ³	Comments
Impoundments					
Unrestricted The use of reclaimed water in an impoundment in which no limitations are imposed on body contact	- Secondary⁴ - Filtration⁵ - Disinfection⁶	- pH = 6.0–9.0 ≤10 mg/L BOD⁷ ≤2 NTU⁸ - No detectable fecal coliform/100 mL^{9,10} 1 mg/L Cl₂ residual (min.)¹¹	- pH – weekly - BOD – weekly - Turbidity – continuous - Fecal coliform – daily - Cl₂ residual – continuous	500 ft (150 m) to potable-water supply wells (min.) if bottom not sealed	- Dechlorination may be necessary to protect aquatic species of flora and fauna. - Reclaimed water should be non-irritating to skin and eyes. - Reclaimed water should be clear and odorless. - Nutrient removal may be necessary to avoid algae growth in impoundments. - Chemical (coagulant and/or polymer) addition prior to filtration may be necessary to meet water quality recommendations. - Reclaimed water should not contain measurable levels of pathogens.¹² - Higher chlorine residual and/or a longer contact time may be necessary to ensure that viruses and parasites are inactivated or destroyed. - Fish caught in impoundments can be consumed. - See Section 3.4.3 in the 2004 guidelines for recommended treatment reliability requirements.
Restricted The use of reclaimed water in an impoundment where body contact is restricted	- Secondary⁴ - Disinfection⁶	≤30 mg/L BOD⁷ ≤30 mg/L TSS ≤200 fecal coliform/100 mL^{9,13,14} 1 mg/L Cl₂ residual (min.)¹¹	- pH – weekly - TSS – daily - Fecal coliform – daily - Cl₂ residual – continuous	500 ft (150 m) to potable-water supply wells (min.) if bottom not sealed	- Nutrient removal may be necessary to avoid algae growth in impoundments. - Dechlorination may be necessary to protect aquatic species of flora and fauna. - See Section 3.4.3 in the 2004 guidelines for recommended treatment reliability requirements.

(continued)

Table 2-4 USEPA suggested guidelines for nonpotable reuse of municipal wastewater¹ (continued)

Reuse Category and Descriptions	Treatment	Reclaimed Water Quality ²	Reclaimed Water Monitoring	Setback Distances ³	Comments
Environmental Reuse					
Environmental Reuse The use of reclaimed water to create wetlands, enhance natural wetlands, or sustain stream flows	- Variable - Secondary⁴ and disinfection⁶ (min.)	Variable, but not to exceed: ≤30 mg/L BOD⁷ ≤30 mg/L TSS ≤200 fecal coliform/100 mL^{9,13,14} 1 mg/L Cl₂ residual (min.)¹¹	- BOD – weekly - SS – daily - Fecal coliform – daily - Cl₂ residual – continuous		- Dechlorination may be necessary to protect aquatic species of flora and fauna. - Possible effects on groundwater should be evaluated. - Receiving water quality requirements may necessitate additional treatment. - Temperature of the reclaimed water should not adversely affect ecosystem. - See Section 3.4.3 in the 2004 guidelines for recommended treatment reliability requirements.
Industrial Reuse					
Once-through Cooling	Secondary⁴	- pH = 6.0–9.0 ≤ 30 mg/L BOD⁷ ≤ 30 mg/L TSS ≤ 200 fecal coliform/100 mL^{9,13,14} 1 mg/L Cl₂ residual (min.)¹¹	- pH – weekly - BOD – weekly - TSS – weekly - Fecal coliform – daily - Cl₂ residual – continuous	300 ft (90 m) to areas accessible to the public	Windblown spray should not reach areas accessible to workers or the public.
Recirculating Cooling Towers	- Secondary⁴ - Disinfection⁶ (chemical coagulation and filtration⁵ may be needed)	Variable, depends on recirculation ratio: - pH = 6.0–9.0 ≤30 mg/L BOD⁷ ≤30 mg/L TSS ≤200 fecal coliform/100 mL^{9,13,14} 1 mg/L Cl₂ residual (min.)¹¹		300 ft (90 m) to areas accessible to the public. May be reduced if high level of disinfection is provided.	- Windblown spray should not reach areas accessible to workers or the public. - Additional treatment by user is usually provided to prevent scaling, corrosion, biological growths, fouling, and foaming. - See Section 3.4.3 in the 2004 guidelines for recommended treatment reliability requirements.

(continued)

Table 2-4 USEPA suggested guidelines for nonpotable reuse of municipal wastewater¹ (continued)

Reuse Category and Descriptions	Treatment	Reclaimed Water Quality ²	Reclaimed Water Monitoring	Setback Distances ³	Comments
Other Industrial Uses – e.g., boiler feed, equipment washdown, processing, power generation, and in the oil and natural gas production market (including hydraulic fracturing) have requirements that depend on site-specific end use (see Chapter 3)					
Groundwater Recharge – Nonpotable Reuse					
The use of reclaimed water to recharge aquifers which are not used as a potable drinking water source.	- Site-specific and use-dependent - Primary (min.) for spreading⁴ - Secondary⁴ (min.) for injection	Site-specific and use-dependent	Depends on treatment and use	Site-specific	- Facility should be designed to ensure that no reclaimed water reaches potable-water supply aquifers. - See Chapter 3 of this manual and Section 2.5 of the 2004 guidelines for more information. - For injection projects, filtration and disinfection may be needed to prevent clogging. - For spreading projects, secondary treatment may be needed to prevent clogging. - See Section 3.4.3 in the 2004 guidelines for recommended treatment reliability requirements.
Indirect Potable Reuse					
<i>Groundwater Recharge by Spreading into Potable Aquifers</i>	- Secondary⁴ - Filtration⁵ - Disinfection⁶ - Soil aquifer treatment	Includes, but not limited to, the following: - No detectable total coliform/100 mL^{9,10} 1 mg/L Cl₂ residual (min.)¹¹ - pH = 6.5–8.5 ≤2 NTU⁸ ≤2 mg/L TOC of wastewater origin	Includes, but not limited to, the following: - pH – daily - Total coliform – daily - Cl₂ residual – continuous - Drinking water standards – quarterly - Other¹⁷ – depends on constituent - TOC – weekly	Distance to nearest potable-water extraction well that provides a minimum of 2 months retention time in the underground	- Depth to groundwater (i.e., thickness to the vadose zone) should be at least 6 ft (2 m) at the maximum groundwater mounding point. - The reclaimed water should be retained underground for at least 2 months prior to withdrawal. - Recommended treatment is site-specific and depends on factors such as type of soil, percolation rate, thickness of vadose zone, native groundwater quality, and dilution. - Monitoring wells are necessary to detect the influence of the recharge operation on the groundwater.

(continued)

Table 2-4 USEPA suggested guidelines for nonpotable reuse of municipal wastewater¹ (continued)

Reuse Category and Descriptions	Treatment	Reclaimed Water Quality ²	Reclaimed Water Monitoring	Setback Distances ³	Comments
		Meet drinking water standards after percolation through vadose zone	- Turbidity – continuous - Monitoring is not required for viruses and parasites; their removal rates are prescribed by treatment requirements		- Reclaimed water should not contain measurable levels of pathogens after percolation through the vadose zone.¹² - See Section 3.4.3 in the 2004 Guidelines for recommended treatment reliability requirements. - Recommended log-reductions of viruses, <i>Giardia</i>, and <i>Cryptosporidium</i> can be based on challenge tests or the sum of log-removal credits allowed for individual treatment processes. Monitoring for these pathogens is not required. - Dilution of reclaimed water with waters of non-wastewater origin can be used to help meet the suggested TOC limit.
<i>Groundwater Recharge by Injection into Potable Aquifers</i>	- Secondary⁴ - Filtration⁵ - Disinfection⁶ - Advanced wastewater treatment¹⁶	Includes, but not limited to, the following: - No detectable total coliform/100 mL^{9,10} 1 mg/L Cl₂ residual (min.)¹¹ - pH = 6.5–8.5 ≤2 NTU⁸ ≤2 mg/L TOC of wastewater origin	Includes, but not limited to, the following: - pH – daily - Turbidity – continuous - Total coliform – daily - Cl₂ residual – continuous - TOC – weekly - Drinking water standards – quarterly	Distance to nearest potable-water extraction well that provides a minimum of 2 months retention time in the underground	- The reclaimed water should be retained underground for at least 2 months prior to withdrawal. - Monitoring wells are necessary to detect the influence of the recharge operation on the groundwater. - Recommended quality limits should be met at the point of injection. - The reclaimed water should not contain measurable levels of pathogens at the point of injection. - Higher chlorine residual and/or a longer contact time may be necessary to ensure virus inactivation.

(continued)

Table 2-4 USEPA suggested guidelines for nonpotable reuse of municipal wastewater¹ (continued)

Reuse Category and Descriptions	Treatment	Reclaimed Water Quality ²	Reclaimed Water Monitoring	Setback Distances ³	Comments
<i>Augmentation of Surface Water Supply Reservoirs</i>	- Secondary⁴ - Filtration⁵ - Disinfection⁶ - Advanced wastewater treatment¹⁶	Meet drinking water standards	- Other¹⁷ – depends on constituent - Monitoring is not required for viruses and parasites; their removal rates are prescribed by treatment requirements		- See Section 3.4.3 in the 2004 Guidelines for recommended treatment reliability requirements. - Recommended log-reductions of viruses, <i>Giardia</i>, and <i>Cryptosporidium</i> can be based on challenge tests or the sum of log-removal credits allowed for individual treatment processes. Monitoring for these pathogens is not required. - Dilution of reclaimed water with waters of non-wastewater origin can be used to help meet the suggested TOC limit.
		Includes, but not limited to, the following: - No detectable total coliform/100 mL^{9,10} 1 mg/L Cl₂ residual (min.)¹¹ - pH = 6.5–8.5 ≤ 2 NTU⁸ ≤ 2 mg/L TOC of wastewater origin - Meet drinking water standards		Site-specific – based on providing 2 months' retention time between introduction of reclaimed water into a raw-water supply reservoir and the intake to a potable-water treatment plant	- The reclaimed water should not contain measurable levels of pathogens.¹² - Recommended level of treatment is site-specific and depends on factor such as receiving water quality, time, and distance to point of withdrawal, dilution, and subsequent treatment prior to distribution for potable uses. - Higher chlorine residual and/or a longer contact time may be necessary to ensure virus and protozoa inactivation. - See Section 3.4.3 in the 2004 Guidelines for recommended treatment reliability requirements. - Recommended log-reductions of viruses, <i>Giardia</i>, and <i>Cryptosporidium</i> can be based on challenge tests or the sum of log-removal credits allowed for individual treatment processes. Monitoring for these pathogens is not required.

(continued)

Table 2-4 USEPA suggested guidelines for nonpotable reuse of municipal wastewater¹ (continued)

Reuse Category and Descriptions	Treatment	Reclaimed Water Quality ²	Reclaimed Water Monitoring	Setback Distances ³	Comments
					Dilution of reclaimed water with water of non-wastewater origin can be used to help meet the suggested TOC limit.

Source: Adapted from US Environmental Protection Agency 2012

BOD: biochemical oxygen demand, NTU: nephelometric turbidity units, SS: suspended solids, TOC: total organic carbon, TSS: total suspended solids

¹ These guidelines are based on water reclamation and reuse practices in the United States and are specifically directed at states that have not developed their own regulations or guidelines. While the guidelines should be useful in many areas outside the United States, local conditions may limit the applicability of the guidelines in some countries. It is explicitly stated that the direct application of these suggested guidelines will not be used by US Agency for International Development (USAID) as strict criteria for funding.

² Unless otherwise noted, recommended quality limits apply to the reclaimed water at the point of discharge from the treatment facility.

³ Setback distances are recommended to protect potable-water supply sources from contamination and to protect humans from unreasonable health risks due to exposure to reclaimed water. Secondary treatment process includes activated sludge processes, trickling filters, rotating biological contractors, and may include stabilization pond systems. Secondary treatment should produce effluent in which both the BOD and SS do not exceed 30 mg/L.

⁵ Filtration means "the passing of wastewater through natural undisturbed soils or filter media such as sand and/or anthracite" or "the passing of wastewater through microfilters or other membrane processes."

⁶ Disinfection means "the destruction, inactivation, or removal of pathogenic microorganisms by chemical, physical, or biological means." Disinfection may be accomplished by chlorination, ozonation, other chemical disinfectants, UV, membrane processes, or other processes.

⁷ As determined from the five-day BOD test.

⁸ The recommended turbidity should be met prior to disinfection. The average turbidity should be based on a 24-hour time period. The turbidity should not exceed 5 NTU at any time. If SS is used in lieu of turbidity, the average SS should not exceed 5 mg/L. If membranes are used as the filtration process, the turbidity should not exceed 0.2 NTU and the average SS should not exceed 0.5 mg/L.

⁹ Unless otherwise noted, recommended coliform limits are median values determined from the bacteriological results of the last 7 days for which analyses have been completed. Either the membrane filter or fermentation tube technique may be used.

¹⁰ The number of total or fecal coliform organisms (whichever one is recommended for monitoring in the table) should not exceed 14/100 mL in any sample.

¹¹ This recommendation applies only when chlorine is used as the primary disinfectant. The total chlorine residual should be met after a minimum actual contact time of at least 90 minutes unless a lesser contact time has been demonstrated to provide indicator organism and pathogen reduction equivalent to those suggested in these guidelines. In no case should the actual contact time be less than 30 minutes.

¹² It is advisable to fully characterize the microbiological quality of the reclaimed water prior to implementation of a reuse program.

¹³ The number of fecal coliform organisms should not exceed 800/100 mL in any sample.

¹⁴ Some stabilization pond systems may be able to meet this coliform limit without disinfection.

¹⁵ Commercially processed food crops are those that, prior to sale to the public or others, have undergone chemical or physical processing sufficient to destroy pathogens.

¹⁶ Advanced wastewater treatment processes include chemical clarification, carbon adsorption, reverse osmosis and other membrane processes, advanced oxidation, air stripping, ultrafiltration, and ion exchange.

¹⁷ Monitoring should include inorganic and organic compounds, that are known or suspected to be toxic, carcinogenic, teratogenic, or mutagenic and are not included in the drinking water standards.

¹⁸ See Section 4.4.3.7 for additional precautions that can be taken when a setback distance of 100 ft (30 m) to potable-water supply wells in porous media is not feasible.

The guidelines include limits for fecal coliform organisms but do not include parasite or virus limits. Where filtration and a high level of disinfection are recommended to produce reclaimed water that is essentially free of measurable levels of pathogens, the guidelines state that it may be necessary to add chemicals prior to filtration to assure complete removal or inactivation of parasites and viruses.

As with state water reuse criteria, the recommendations in Table 2-4 are principally directed at health protection and include various control measures. For example, for nonpotable urban uses of reclaimed water, the guidelines include the following recommendations: clear and odorless product water; a setback distance of 15 m (50 ft) from irrigated areas to potable-water supply wells; no measurable levels of pathogen organisms in the reclaimed water; maintenance of a chlorine residual of at least 0.5 mg/L in the distribution system; treatment reliability and emergency storage or disposal of inadequately treated water; and cross-connection control devices on potable-water service lines and color-coded or taped reclaimed-water lines and appurtenances. Similar design and operational recommendations are included in the guidelines for the other reclaimed-water nonpotable applications.

It is explicitly stated in the *Guidelines for Water Reuse* that the recommended treatment unit processes and water quality limits presented in the guidelines “are not intended to be used as definitive water reclamation and reuse criteria. They are intended to provide reasonable guidance for water reuse opportunities, particularly in states that have not developed their own criteria or guidelines” (USEPA 2012).

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