Part 1

WATER REUSE: AN INTRODUCTION

The social, economic, and environmental impacts of past water resources development and inevitable prospects of water scarcity are driving the shift to a new paradigm in water resources management. New approaches now incorporate the principles of sustainability, environmental ethics, and public participation in project development. With many communities approaching the limits of their available water supplies, water reclamation and reuse have become an attractive option for conserving and extending available water supply by potentially (1) substituting reclaimed water for applications that do not require high-quality drinking water, (2) augmenting water sources and providing an alternative source of supply to assist in meeting both present and future water needs, (3) protecting aquatic ecosystems by decreasing the diversion of freshwater, reducing the quantity of nutrients and other toxic contaminants entering waterways, (4) reducing the need for water control structures such as dams and reservoirs, and (5) complying with environmental regulations by better managing water consumption and wastewater discharges.

Water reuse is particularly attractive in the situation where available water supply is already overcommitted and cannot meet expanding water demands in a growing community. Increasingly, society no longer has the luxury of using water only once. Part 1 serves as an introduction to the general subject of water reuse. Current and potential water shortages, principles of sustainable water resources management, and the important role of water reclamation and reuse are discussed in Chap. 1. An overview of existing water reclamation and reuse applications and issues is presented in Chap. 2, which also serves as an introduction to the subsequent chapters.

第 1 部分

水回用：概述

过去水资源开发产生的社会、经济和环境影响以及水资源不可避免的匮乏使人们正在寻求新的水资源管理方式。当代新的管理手段融合了可持续性原理、环境伦理以及项目开发中的公众参与。许多区域可以获得的供水量正接近其极限值，因此，水再生及回用已经成为保护及增加供水的颇具吸引力的选择手段：

（1）将再生水用于不需要高质量饮用水的场合；

（2）为帮助满足目前和将来的水需求，扩大水源并提供可代替的供水水源；

（3）减少淡水的调水量，减少营养物质以及其他毒性及生物进入水域的量，保护水生生态系统；

（4）减少对水控制设施，如水坝、水库的需求；

（5）更好地管理水消耗和废水排放，遵守环境法规。

在社区不断增加的情况下，当可以得到的供水量已经受到限制并且不能满足日益增加的水需求时，水回收就会特别有吸引力。人们已不再像过去那样奢侈地用水了。第 1 部分为水回用的一般性概述部分。第 1 章讨论目前的和潜在的水短缺状况，水资源可持续管理的原理，以及水再生和回用的重要作用。第 2 章涉及水再生和回用方面目前存在的问题，也作为后续章节的导论。

1 Water Issues: Current Status and the Role of Water Reclamation and Reuse
水问题：水再生和回用的现状及作用

WORKING TERMINOLOGY 专用术语

Term	Definition
Agricultural water use	Water used for crop production and livestock uses.
Aquifer	Geological formations that contain and transmit groundwater.
Beneficial uses	The many ways water can be used, either directly by people, or for their overall benefit. Examples include municipal water supply, agricultural and industrial applications, navigation, fish and wildlife habitat enhancement, and water contact recreation.
Consumptive use	The part of water withdrawn that is evaporated, transpired, incorporated into products or crops, consumed by humans or livestock, or otherwise removed from the immediate water environment.
Direct potable reuse	See Potable reuse, direct.
Domestic water use	Domestic water use includes water for normal household purposes, such as drinking, food preparation, bathing, washing clothes and dishes, flushing toilets, and watering lawns and gardens.
Ecoefficiency	The efficiency with which environmental resources are used to produce a unit of economic activity.
Environmental ethics	A discipline of ethics that explores moral responsibility in relation to the environment.
Evapotranspiration	A collective term that includes loss of water from the soil by evaporation and by transpiration from plants.
Global hydrologic cycle	The annual accounting of the moisture fluxes over the entire globe in all of their various forms.
Groundwater	The subsurface water that occurs beneath the water table in soils and geologic formations that are fully saturated and supplies wells and springs.
Groundwater recharge	The infiltration or injection of natural waters or reclaimed waters into an aquifer, providing replenishment of the groundwater resource or preventing seawater intrusion.
Indirect potable reuse	See Potable reuse, indirect.
Industrial water use	Water used in industrial operations and processes. The principal industrial water users are thermal and atomic power generation.
Irrigation water use	Artificial application of water on lands to assist in the growing of crops and pastures or to maintain vegetative growth in recreational lands such as parks and golf courses.
Integrated water resources planning	A process that promotes the coordinated development and management of water, land, and related resources to maximize the resultant economic and social welfare in an equitable and sustainable manner.
Landscape irrigation	Irrigation systems for applications such as golf courses, public parks, playgrounds, school yards, and athletic fields.
Municipal water use	The water withdrawals made by the populations of cities, towns, and housing estates, and domestic and public services and enterprises. Also includes water used to provide directly for the needs of urban populations, which consume high-quality water from city water supply systems.
Nonpotable reuse	All water reuse applications that do not involve either indirect or direct potable reuse.
Per capita water use	The average amount of water used per person during a standard time period, usually per day.
Potable water	Water suitable for human consumption without deleterious health risks. The term drinking water is a preferable term better understood by the community at large.

Potable reuse, direct	The introduction of highly treated reclaimed water either directly into the potable water supply distribution system downstream of water a treatment plant, or into the raw water supply immediately upstream of a water treatment plant (see Chap. 24).
Potable reuse, indirect	The planned incorporation of reclaimed water into a raw water supply such as in potable water storage reservoirs or a groundwater aquifer, resulting in mixing and assimilation, thus providing an environmental buffer (see Chaps. 22 and 23).
Public water supply	Water withdrawn by public and private water suppliers and delivered to multiple users for domestic, commercial, industrial, and thermoelectric power uses.
Reclaimed water	Municipal wastewater that has gone through various treatment processes to meet specific water quality criteria with the intent of being used in a beneficial manner (e.g., irrigation). The term recycled water is used synonymously with reclaimed water, particularly in California.
Renewable water resources	The water entering a country's surface and groundwater systems. Not all of this water can be used because some falls in a place or time that precludes tapping it even if all economically and technically feasible storage and diversion structures were built.
Return flow	The water that reaches a ground- or surface-water source after release from the point of use and thus becomes available for further use.
Runoff	Part of the precipitation that appears in surface streams. It is the same as streamflow unaffected by artificial diversions, storage, or other works of man in or on the stream channels.
Sustainability	The principle of optimizing the benefits of a present system without diminishing the capacity for similar benefits in the future.
Sustainable development	Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.
Transpiration	Water removed from soil that undergoes a change-of-state from liquid water in the stomata of the leaf to the water vapor of the atmosphere.
Wastewater	Used water discharged from homes, business, cities, industry, and agriculture. Various synonymous uses such as municipal wastewater (sewage), industrial wastewater, and stormwater.
Water reclamation	Treatment or processing of wastewater to make it reusable with definable treatment reliability and meeting appropriate water quality criteria.
Water reuse	The use of treated wastewater for a beneficial use, such as agricultural irrigation and industrial cooling.
Watershed	The natural unit of land upon which water from direct precipitation, snowmelt, and other storage collects and flows downhill to a common outlet where the water enters another water body such as a stream, river, wetland, lake, or the ocean.
Withdrawals	The water removed from the ground or diverted from a stream or lake for use.

The feasibility and reliability of providing adequate quantities and quality of water to meet societal needs is constrained by geographic, hydrologic, economic, and social factors. Projections of unprecedented global population growth, particularly in urban areas, have fueled concerns about water availability in increasingly complex environmental, economic, and social settings. Some of the important questions and concerns are: (1) how long can existing water sources be sustained? (2) how can we ensure the reliability of current and future water sources? (3) where will the next generation of water sources be found to meet the needs of growing populations and uses and provide for agriculture

and industrial water requirements? and (4) how will conflicts between watershed interests in environmental preservation and beneficial uses of water sources be resolved? To address the social, economic, and environmental impacts of water resources development and avert the ominous prospects of water scarcity, there is a critical need to reexamine the way water resources systems are planned, constructed, and managed.

The emerging paradigm of sustainable water resources management emphasizes whole-system solutions to reliably and equitably meet the water needs of present and future generations. Understanding the concepts of sustainable water resources management as a foundation of water reclamation and reuse is of fundamental importance. Thus, the purpose of this introductory chapter is to provide a perspective on (1) a definition of terms including working terminology used in this chapter, (2) principles of sustainable water resources management, (3) current and potential future global water shortages, (4) the important role played by water reclamation and reuse, and (5) the future of water reclamation and reuse. The discussion in this chapter is designed to stimulate readers to think about future water resources development and management in more sustainable and comprehensive ways, incorporating water reclamation and reuse as one of the viable options.

1-1 DEFINITION OF TERMS 术语定义

Several different terms are used to describe forms of water and wastewater and their subsequent treatment and reuse. To facilitate communication among different disciplines associated with water reclamation and reuse practices, it is important to establish a broad understanding of the terminology used in the field of water reclamation and reuse. Useful terminology related to water reclamation and reuse is presented as Working Terminology at the beginning of this chapter and every chapter in this textbook.

For the purpose of gaining broader public acceptance of water reuse, in 1995 the State of California amended the provisions of the existing Water Code substituting the term *recycled water* for *reclaimed water* and the term *recycling* for *reclamation* (State of California, 2003). *Water recycling* is defined to mean water, which as a result of treatment of wastewater, is suitable for a direct beneficial use or a controlled use that would not otherwise occur. However, because of the traditional usage of the word and the practice in water reclamation and reuse, the terms *reclaimed water* and *recycled water* are used synonymously in this textbook. It should be noted that the terminology given above may be considered *working definitions* that have evolved from water and wastewater treatment, several water reuse legislations and regulations, as well as in response to questions raised by reclaimed water users and the public at large.

1-2 PRINCIPLES OF SUSTAINABLE WATER RESOURCES MANAGEMENT 可持续水资源管理的原则

Historically, water resources management has focused on supplying water for human activities, with an intrinsic assumption that technological solutions would keep pace with steadily increasing water demands and progressively more stringent water quality requirements. Past water resources development was based on manipulating the natural