WATER QUALITY AND TREATMENT

A HANDBOOK ON DRINKING WATER

American Water Works Association

James K. Edzwald, Technical Editor

Professor Emeritus, University of Massachusetts

Sixth Edition

McGraw- Hill

American Water Works Association is the authoritative resource for knowledge, information and advocacy to improve the quality and supply of water in North America and beyond. AWWA is the largest organization of water professionals in the world. AWWA advances public health, safety and welfare by uniting the efforts of the full spectrum of the entire water community. Through our collective strength we become better stewards of water for the greatest good of the people and the environment.

American Water Works Association

6666 W. Quincy Ave.

Denver, Colorado 80235

www.awwa.org

AWWA Director of Publishing: Monica Joda Baruth

AWWA Publications Manager: Gay Porter De Nileon

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PREFACE

This 6th edition of *Water Quality and Treatment: A Handbook on Drinking Water* serves as a handbook for scientists, engineers, and other professionals who study and work in drinking water; particularly, the quality of water supplies, the quality of treated drinking water, and water treatment processes. It is meant as a resource for those in academics (professors and students); consulting engineering practice; water utilities; federal and state regulatory agencies; and the water process and chemical industries. The book emphasizes principles (theory) and applications (practice). It serves as a companion to the book on design, AWWA–ASCE *Water Treatment Plant Design*; the 5th edition is in preparation with expected publication in late 2011.

This book is an activity of AWWA's Water Quality and Technology Division (WQTD). James K. Edzwald served as the technical editor and worked with the authors of the chapters in preparing the book. An ad hoc committee of the WQTD consisting of James P. Malley, Jr., Marilyn M. Marshall, and Dixie Fanning provided advice to the technical editor throughout the preparation of the book.

Water Quality and Treatment, 6th edition, differs greatly from the 5th edition published in 1999; it contains significant revisions, updating of material, and new chapters. Five new chapters expand the scope of this book: Chapter 4, Hydraulic Characteristics of Water Treatment Reactors and Their Effects on Treatment Efficiency; Chapter 15, Natural Treatment Systems; Chapter 16, Water Reuse for Drinking Water Augmentation; Chapter 18 UV Light Process*es*; and Chapter 19, Formation and Control of Disinfection Byproducts. A sixth chapter, Chapter 3, Chemical Principles, Source Water Composition, and Watershed Protection, replaces one from the 5th edition on source water quality management, and it is essentially another new chapter in that it contains new material on chemical principles and additional material on source water quality.

Since publication of the 5th edition in 1999, the drinking water field has faced new regulations and concerns about the health effects of some new and previously known contaminants. Furthermore, in the last 10 years we have seen the development of new technologies and refinements of older technologies that are now covered in this edition. The 6th edition covers the health effects and treatment technologies to remove some contaminants not covered previously such as nanoparticles, endocrine-disrupting compounds, and pathogens; it contains updated material on many other contaminants such as disinfection by-products, arsenic, and pathogens including viruses and protozoan cysts such as *Cryptosporidium*; and it addresses

subjects not adequately covered in the prior edition, such as water reuse, ultraviolet light processes, and natural treatment systems.

Several other new features are notable in this 6th edition. The International System of Units (SI) is used with U.S. units in parenthesis where appropriate. This makes the book useful to professionals outside the United States and to those within the United States working on water projects around the world. Each chapter has its own table of contents to aid readers in finding subject matter within chapters. Four new appendices provide quick references for atomic numbers and masses, physical and chemical constants, unit conversion factors, and the physical properties of water.

The book is organized beginning with five supporting chapters that contain material on drinking water standards and regulations (chapter 1), health effects (chapter 2), chemical principles, source water composition, and watershed protection (chapter 3), hydraulics of treatment processes (chapter 4), and an overview of water treatment processes (chapter 5). This is followed by coverage of various water treatment processes in chapters 6 through 14 that present principles and applications of the removal of various contaminants from water supplies. Chapter 15 covers natural treatment systems such as river bank filtration, and chapter 16 deals with water reuse. Chapters 17 and 18 follow with disinfection and UV light processes including disinfection and advanced oxidation processes. Chapters 19, 20, and 21 cover disinfection byproducts, corrosion, and microbiological quality in distribution systems, respectively. Chapter 22 ends the book with the properties, treatment, and management of water treatment residuals.

James K. Edzwald
Technical Editor
Professor Emeritus, University of Massachusetts

James P. Malley, Jr.
Chairman of the Board of Trustees, AWWA Water Quality and Technology Division
Professor, University of New Hampshire

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The revision of the book began with an assessment of the 5th edition. Several professionals from water utilities, consulting engineering firms, and academics were asked to review the 5th edition and to make recommendations for new material for inclusion in the 6th edition. I wish to thank the following: William C. Becker (Hazen and Sawyer), William D. Bellamy (CH2M Hill), Steve Bishop (Metcalf and Eddy), Howard Dunn (Vice President of Operations and Technology, Aquarion Water Company of CT), Harold T. Glaser (Kennedy Jenks), Raymond D. Letterman, (Syracuse University and Technical Editor of the 5th edition), Michael J. MacPhee (Malcolm Pirnie), Charles R. O'Melia (Johns Hopkins University), Vernon L. Snoeyink (University of Illinois), and John P. Walsh (formerly, Director of Operations and Distribution, Aquarion Water Company of CT, now with Tighe and Bond).

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James K. Edzwald
Technical Editor
Professor Emeritus, University of Massachusetts