



WATER RESOURCES HANDBOOK

LARRY W. MAYS

WATER RESOURCES HANDBOOK

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PREFACE

Water affects the life of every human on Earth: too little or too much can be detrimental to our livelihood; the quality affects our health and well-being; and the beauty can be found in the many streams, rivers, lakes, estuaries, and oceans. If you ask a child what water means to them, they might write a poem about water similar to what my twelve-year-old son, Travis, wrote, called "Water, Water, Everywhere":

Calm and glistening
Sparkles like many crystals
Clear and beautiful
You drink it every day
Sparkling and clear water

Unfortunately, as we all know, there is much more to the poem that can be written, not so optimistically.

In her book *Silent Spring*, Rachel Carson presented some selected quotes in the front pages. The first is by Albert Schweitzer: "Man has lost the capacity to foresee and to forestall. He will end by destroying the Earth." The second is by E. B. White:

I am pessimistic about the human race because it is too ingenious for its own good. Our approach to nature is to beat it into submission. We would stand a better chance of survival if we accommodated ourselves to this planet and viewed it appreciatively instead of skeptically and dictatorially.

In the last chapter of *The Other Road*, Rachel Carson wrote:

The road we have long been traveling is deceptively easy, a smooth superhighway on which we progress with great speed, but at its end lies disaster. The other fork of the road—the one "less traveled by"—offers our last, our only chance to reach a destination that assures the preservation of our earth.

After having thought about these many times I am optimistic that the human race has the ability to foresee and is not too ingenious for its own good, that we will not beat nature into submission. We will survive as we continue to learn how to accommodate ourselves to this planet and view it appreciatively. Hopefully, we have taken, and will continue to take, the other fork of the road in the development and utilization of our water resources on Earth. Let the effort in developing this handbook be a contribution to that process of learning how to accommodate ourselves on this planet.

During the past few decades, water resources and the related fields have undergone a revolution in scientific development and in methods available for analysis and design. The advent of the computer has changed our entire thought process and

ability to understand and model complex processes as well as archive and analyze voluminous amounts of data. Such abilities were simply impossible only a few decades ago. A major emphasis of this book is to present the state of the art of the many topics related to water resources.

First and foremost, this handbook is intended to be a reference book for those wishing to expand their knowledge of water resources. The handbook can be used as a companion along the pathway of learning about water resources in general or about special topics in water resources. It can be used to begin the journey and/or to continue the journey, as a road map to other publications and specific topics beyond the intent of this handbook. The handbook should serve as a reference to engineers, planners, economists, attorneys, managers, hydrologists, designers, policy makers, geologists, political scientists, biologists, educators, ecologists, limnologists, geographers, public administrators, resource developers, environmentalists, soil scientists, and others.

The field of water resources is diverse, resulting in a wide range of subject matter that should be covered in a water resources handbook. The handbook subject matter selected reflects my personal perception of water resources. The chapters were therefore chosen to reflect what I feel are the most directly related topics to the widest range of readers with an interest in water resources. Space limitations, however, did not allow for an all-inclusive treatment of all fields related to water resources. Examples include many related topics in the biological sciences, physical sciences, social sciences, and engineering.

The handbook comprises five sections: Principles for Water Resources, Chapters 1 to 7; Water Quality of Natural Systems, Chapters 8 to 14; Water Resource Supply Systems, Chapters 15 to 23; Water Resources Excess Management, Chapters 24 to 28; and Water Resources for the Future, Chapters 29 to 33. My intent was that these five sections cover the major topics of a water resources handbook, at least within the framework in which I have thought about water resources for many years. The individual chapters were then chosen to cover the topics I felt were most important for these five sections. I sincerely hope you find what you need in this handbook or at least the information to lead you in the right direction on your pathway of learning about water resources.

Larry W. Mays

ACKNOWLEDGMENTS

I must first acknowledge the authors who made this handbook possible. It has been a sincere privilege to have worked with such an excellent group of dedicated people. They are all experienced professionals who are among the leading experts in their respective fields. References to material in this handbook should be attributed to the respective chapter authors.

Each chapter was reviewed by professionals in their particular area of expertise. I would like to thank each of those people for their time and effort. You have certainly been a major contribution to the completion of this handbook.

During the past twenty years of my academic career I have received help and encouragement from so many people that it is not possible to name them all. These people represent a wide range of universities, research institutions, government agencies, and professions. To all of you I express my deepest thanks.

I would like to acknowledge the support that I have received from Arizona State University. Even though I have served as Chair of the Department of Civil and Environmental Engineering during this time, my efforts were made possible through the hard work and dedication of Debbie Trimmels and Ethel Bruce of my staff, who not only helped on this handbook but also kept the department going. A special thanks goes to Professor Paul Ruff, the associate chair of the department, who kept things going in my absence and who covered me in meetings when I could not attend. A very special thanks goes to Dr. Guihua Li, who helped in many ways, including work on the many figures and permissions.

I appreciate the advice and encouragement of Larry Hager of McGraw-Hill. Last of all, I would like to give a special thanks to Ginny Carroll and team of North Market Street Graphics in Lancaster, Pennsylvania, who were in charge of the handbook production.

This handbook has been part of a personal journey that began over forty years ago when I was a young boy with a love of water. Books are companions along the journey of learning. I hope that you will be able to use this handbook in your own journey of learning about water resources. Have a happy and wonderful journey.

I would like to dedicate this handbook to humanity and human welfare.

Larry W. Mays

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Larry W. Mays, Ph.D., P.E., P.H., is professor and chair of the Civil and Environmental Engineering Department at Arizona State University. He was formerly director of the Center for Research in Water Resources at the University of Texas at Austin, where he held an Engineering Foundation Endowed Professorship.

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