Preface

Freshwater supplies are dwindling as global population growth, industrialization, and agricultural expansion occur worldwide. Desalination of seawater is rapidly becoming a key aspect of global water management to balance the needs of numerous coastal countries, particularly in arid lands and industrialized counties. Seawater desalination is an energy-intensive process that has some real and perceived environmental impacts. Therefore, it is important to reduce the energy consumption of desalination, the carbon footprint, the environmental impacts, and the overall cost. Currently, the most energy efficient desalination large-scale commercial process is seawater reverse osmosis (SWRO).

It is the purpose of this book to address two important aspects of the SWRO process, design of intakes and outfalls and assessment and reduction of environmental impacts. Most of the book content is based on technical presentations made at an international workshop on desalination system intakes and outfalls sponsored and held during October 7–8, 2013 at the King Abdullah University of Science and Technology (KAUST) in Thuwal, Saudi Arabia. Additional chapters were solicited by the editors to cover various aspects of intakes and outfalls not occurring during the workshop.

The Water Desalination and Reuse Center and the Red Sea Research Center at KAUST jointly organized the workshop with generous support from KAUST's Office of Research Support. The presence of KAUST on the Red Sea, where increasing urbanization and industrialization along the coast demands additional freshwater supply, provided much of the impetus for the workshop. Saudi Arabia currently produces about 18 % of the global production of desalinated water with an expected capacity of nearly 6 million cubic meters per day in 2015. Over the long term the dependence on desalinated water in the region and much of the world will only increase. A long-term goal of this workshop and similar efforts is to reduce the energy intensity and increase water-use efficiency throughout the life cycle of desalination plants, minimizing environmental impacts to the greatest extent possible. In other words, the goal is to develop desalination plant design that promotes sustainable interaction of the human environment within our natural environment.

This book covers a considerable number of subjects that have not been published extensively in the peer-reviewed literature. The book is divided into two major sections; intakes and outfalls with some overlapping subject matter involving environmental impact assessment and reduction. The intakes section is further subdivided into surface or "open-ocean" intakes and subsurface intakes.

The overall design philosophy of intakes for SWRO plants is covered in Chap. 1. Design concepts for velocity-cap, and tunnel intake systems are covered in Chaps. 2–3. The very important issue of impingement and entrainment is covered in Chap. 4, which includes a summary of the latest U.S. environmental regulations and a summary of research. Design and impacts of passive screen intake systems are discussed in detail in Chap. 5. In recent years it has been suggested that deep intake systems could be used to obtain higher quality feed water for SWRO systems. In Chap. 6, the use of deep intakes along the Red Sea coastline of Saudi Arabia is assessed. This comprehensive study shows the variation in algae, bacteria, and various types of natural organic matter with depth in the Red Sea and how the bathymetric features of the Red Sea impact deep intake system feasibility.

Discussion of subsurface intake systems begins with Chap. 7, which provides a comprehensive planning methodology that is used to analyze the Red Sea coastal areas of Saudi Arabia and the coasts of Florida to assess technical feasibility of using various subsurface intake systems. Use of wells as intakes, the most mature subsurface intake technology, is covered in Chap. 8 with an assessment of the improvement in raw water quality that occurs between the raw seawater and after traveling through an aquifer to a production well occurring in Chap. 9. Beach and seabed gallery intake system design and innovations in their use are covered in Chaps. 10–12. Applications of seabed gallery feasibility for the Red Sea and Arabian Gulf coasts and nearshore areas of Saudi Arabia are discussed in detail in Chaps. 11 and 12. The generally new concept of using slant wells as intakes is discussed in Chap. 13. The application of coastal modeling to assess the technical feasibility of developing gallery intake systems, with an emphasis on southern California, is covered in Chap. 14. The innovations in design and operation of SWRO intake system are summarized in Chap. 15.

The second part of the book covers assessment and mitigation of environmental impacts associated with discharge of concentrate from SWRO plants and subsequent wastewater discharge. Overall, this group of papers progresses from modeling approaches for coastal discharges.

Chapter 16 provides an overall of coastal discharges and how they are managed. Chapter 17 discusses the results of laboratory modeling of various configurations of concentrate diffusers, their performance and design criteria, and applications. Chapter 18 builds from the nearfield modeling toward a tiered approach of nearfield and farfield modeling, observation, and analysis for design, placement, and implementation of new facilities. Additional evaluations and design criteria for dense brine discharges are provided in Chap. 19. Chapter 20 presents a modeling evaluation of the dispersion of heat and salt from a discharge in the Gulf of Arabia and the response of the dispersion to variations in the coastal currents. Because the

Red Sea is an enclosed basin, discharges within that basin may have impacts that can spread either along the coast or even across the axis of the basin. The model results described in Chap. 21 demonstrates the potential for that very farfield dispersion. Chapter 22 discusses the use of AUV's for farfield mapping and long-term deployments building a statistical database that can be used for comparison against numerical models where the resolution is now approaching the scale of the near-field. Chapter 23 discusses the innovations in management of coastal discharges and evaluation of environmental impacts.

The purpose of this book is to provide the latest summary of pertinent research on intake and outfall design concepts for SWRO facilities. It should be used by design engineers, geologists, project owners, and facility operators for use as a reference and to obtain new ideas that could produce innovative designs that will reduce the energy consumption and operational costs of SWRO facilities. Also, we have provided summaries of where additional scientific and engineering research should be conducted to make improvements to intake and outfall performance.

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