Preface

This writing project began as a book on a number of issues affecting drinking water and governmental policy on water resource management. But the range and depth of the material on the subject necessitated that it be split into two companion books, each of which could be read and appreciated independently of the other. The title of the first is "Global Drinking Water Management And Conservation: Optimal Decision-Making." This book is now in print; its focus is on a number of theoretical principles that should guide water resource management and drinking water production, both in the developed and the developing countries. It makes sense to bring these theoretical principles under one cover, especially this year, as this is the United Nations "International Decade for Action, Water for Life, 2005–2015." This companion book includes a summary of the principles covered in the first book, but focuses on water policy in Canada. However, each book can be read independently of the other.

The two books add to a considerable body of research on water issues. In a series of books and reports, Dr. Peter Gleick, President of the Pacific Institute, has carried out painstaking research on a large number of issues relevant for the sustainable use of water resources. His last biannual report was released in January 2014. The near- to medium-term urgent impacts of climate change on water have also been researched by Canadian scientists. This technical work has been very ably summarized by Dr. Robert Sandford in his 2012 book entitled "Cold Matters: The State and Fate of Canada's Fresh waters," published by Rocky Mountain Books. A paragraph from that book is worth quoting:

> …Canada's hydrological systems…are on the move. The natural variability in rain and snowfall, river flows, lake levels…are all changing. In scientific terms Canada is experiencing a loss of hydrological stationarity. As a result, precipitation and river flows will be different from what we have come to expect. New ranges of variability will emerge. There will be more and more times when that variability will be outside the range for which our urban and rural infrastructure was designed to function. There will be more times when climate variability will be outside our current ability to adapt… The loss of hydrological stationarity will void traditional approaches to how we assess risk in the design of buildings, roads, storm sewers and water treatment systems (Sandford 2012, p. 230).

Dr. Sandford, who has kindly written the Foreword to this book, was summarizing research focused on northern Canada. But these same changes will have reverberations right across Canada. Climate change is already affecting all parts of Canada (Dore and Simcisko 2013) and its main impact is likely to be on public infrastructure as stated in the quotation given above. This means that water conservation and judicious water management is becoming ever more urgent.

The concern of this set of two books is the management of drinking water, although this cannot be divorced from sustainable water resource management for ecosystem health, the overarching philosophy for sustainable use that German and other European authorities have explicitly recognized. Maintenance and restoration of ecosystem functioning and health *within a context of climate change* ought now to be recognized as being synonymous with the "social good." In Chap. 8 on water policy in British Columbia we discuss the legislation of the 2014 *Water Sustainability Act*, in which the province of British Columbia moved partly in that direction, but there is still inadequate protection for watersheds and inadequate recognition of impending hydrological changes. However, there is recognition of the need to preserve ecosystem health, if only to protect jobs and incomes.

All over the globe environmental damage can be seen in stresses on land, air, oceans, and freshwater. It is clear that in much of the world the "social good" is being very narrowly defined. The stress on water resources is due not only to economic development of middle income and poorer countries but also to the loss of hydrological stationarity mentioned above. The emerging evidence on climate change indicates that the northern hemisphere is getting wetter, but some pockets of dry areas are likely to get even drier, such as the mid-southwest of the United States and drier areas of western Canada. On the other hand in Africa, desertification is advancing and flow rates in the existing rivers and lakes are becoming more variable. Areas in Southern Europe can also expect increasing water stress. Under these conditions, conservation of water has increased in importance. Some water-stressed areas are beginning to look for inter-basin water transfers, but these are unsound from the perspective of ecosystem health. There is also growing evidence of water conflicts becoming more prominent. A large trade in drinking water in the form of bottled water exists but there is also a search for bulk water exports. For example much of Canada's water flows north, but from time to time there are fears of the possibility of bulk water export or diversion of freshwater from the northern rivers and the Great Lakes into the Mississippi River though the Chicago Diversion for the growing population of the US "sunbelt" (Dore and Whorley 2006). Similarly Turkey has proposed bulk water exports to Israel. Some inter-basin transfers, such as those from the Great Lakes to the south of the US have the potential for future conflict.

Inter-basin water transfers and the potential for conflict can be avoided if there is in place a committed policy of water conservation in order to ensure that ecosystem health is ranked as a priority in water resource management all over the globe. This primary aim needs to be supplemented with systemic adaptation to the changing availability of fresh water due to climate change. However, rapid (though uneven) economic development is making water scarcity a major threat. As fresh and clean

water supply comes under stress, most drinking water is no longer pristine and must be treated for pathogens and other contaminants. In North America, the treatment method relies largely on chlorine, primarily to kill bacteria and viruses. But the threats from protozoa remain, and these have led to a number of waterborne disease outbreaks, as chlorine is ineffective against a number of pathogens, as this books shows.

The production of drinking water requires adequate management, with appropriate pricing and management under risk, an idea that the World Health Organization has been promoting in order to reduce or eliminate waterborne disease outbreaks. In the first of the two books, the major theoretical issues in the management of drinking water are considered in some detail. These issues are: (1) watershed protection from harmful human industrial, mining and agricultural activity; (2) characteristics and efficacies of drinking water treatment technologies and their unit costs under conditions of economies of scale; (3) theory and practice of water pricing; (4) methods and processes of adopting risk assessment in drinking water management; (5) up-to-date water infrastructure management incorporating risk; (6) a serious commitment to overcoming risks to long-term health through reduced reliance on chlorine and chlorine derivatives for disinfection; (7) the need for an adequate response to the threat of lead in in drinking water; and (8) overcoming the current inadequate treatment of wastewater discharged into surface waters that become the source of drinking water, with the concomitant presence of micro-pollutants in the drinking water. All that is the subject of the first book. In this companion book, the focus is on conservation and on government-level policy on water in Canada and the extent to which cattle farming, mining, and oil and gas drilling, and possibilities of oil pipelines threaten both the land environment and freshwater resources. In other words, agriculture and industry are not bearing the full *social cost* of their activities. As water is a provincial responsibility, there are separate chapters on water policy in four provinces: Ontario, Alberta, British Columbia, and Newfoundland and Labrador.

Drinking water supply is organized in a number of ways in developed countries. Some large cities in Europe operate water supply as a private but regulated business. However, in much of the world water is almost exclusively provided by a local municipality, as a local 'public' good. Naturally in this case there is no profit motive, and no incentive to innovate, introduce more advanced technology, or to improve water quality. The European private companies and other pockets of privatized water companies seem well managed, but it is not clear that they are innovators in delivering higher water quality. What seems to lead to higher quality drinking water is government leadership through adequate regulation, as in Denmark, the Netherlands, and Germany. Public awareness of what is possible and what has been done in other jurisdictions may perhaps drive citizens and their utilities to improve water quality.

There are two long-term threats to health associated with the treatment and delivery of drinking water: one is the presence of lead in drinking water, which is a serious health hazard. It is therefore imperative that the lead content of drinking water is properly measured; there are two chapters that deal with lead in drinking

water in the first book (Dore 2015, Chaps. 10 and 11). The other long-term threat is the use of chlorine and chlorine derivatives used in the disinfection of drinking water, which is also covered in the first book (Chap. 9). The use of chlorine results in a large number of "disinfection byproducts," some of which are regulated in the developed countries. But chlorine alone is ineffective against protozoa, and the byproducts carry some very long-term threats to human health. There are new treatment technologies that do not have these byproducts and are therefore safer. These newer technologies can be used to deliver a higher quality of water, but there appears to be a lack of knowledge of these possibilities, and possibly apathy among North American governments. Consumers might demand better water quality if they had more information on the new technologies and their costs.

Communities in Europe seem more cognizant of some of the long-term threats to health associated with the use of chlorine as a primary disinfectant, but other threats due to lead in the water remain a major concern, although there are some European countries (like Denmark) where this threat is taken very seriously and largely eliminated. But in the rest of the world the presence of lead in old pipes and even in the treatment systems continues to be a concern. For the threat of lead, what is required is a scientifically sound lead sampling protocol and an appropriate maximum contamination level (MCL) set as a regulation. It would also help if there were a systematic plan to eliminate all lead pipes and fixtures.

Most developed countries have strong regulations against the presence of pathogens and once lead is eliminated, the next frontier in water quality will be the elimination of chemical contaminants such as *pesticides* (e.g. *atrazine*), *herbicides*, *pharmaceuticals and personal care products*. This is a problem when the source water comes from multi-use watersheds like the Great (North American) Lakes. Europe (for example, Germany and the Netherlands) has made real progress in dealing with these problems; most European jurisdictions have moved away from surface water as a source and switched to groundwater, which by itself is a natural form of "treatment"; groundwater is often free of contaminants except where there are known contaminants, such as iron and manganese. The proper treatment of wastewater to the tertiary level is another urgent need and here again countries like Germany, Denmark, and the Netherlands have made remarkable progress.

It could be argued that smaller countries like Denmark and the Netherlands can afford to be aggressive in assuring better quality of water. But the comparative case study of Germany reported in this book shows what can be done to improve drinking water quality by avoiding some of the long-term risks. Germany offers some important lessons both for North America and for the developing world on how water supply could and should be managed.

I hope that the coverage of these important topics in the management and delivery of clean water will stimulate discussion on what can be learnt from Germany to help improve drinking water quality everywhere, including the developing countries. Thus the two books are oriented toward filling the knowledge gap and showing the potential for improvement. As such both books are likely to be of interest to water system owners, managers, water engineering consultants, and regulators all over the world. The comparative dimension may also appeal to some

readers, to see how some jurisdictions manage their water supply as a public service producing a product essential to life.

I should like to record all the help that I have received in writing this and the companion book. First, the two books would not have been possible without the research grants that I have been fortunate enough to receive from the Social Sciences and Humanities Research Council of Canada (SSHRC), The National Science and Engineering Council of Canada (NSERC), the Canadian Foundation for Climate and Atmospheric Sciences (CFCAS),[1] the US National Science Foundation (US-NSF), the Climate Change Action Fund of the Federal Government of Canada, and grants for teaching release from Brock University, which in turn were possible thanks to the Research Time Release Stipends included in my SSHRC grants over the last few years. The research grants enabled me to establish my Climate Change Lab at Brock University. In this lab I was fortunate in hiring many of my students as research assistants, and most of them wrote their graduate or undergraduate honors theses under my supervision in the lab. They have greatly influenced my thinking and many contributed important germs of new ideas, and new models as vehicles of inquiry; these dramatically altered my thinking, as teaching is a two-way enriching process. I want to record my debt to all my former students, who are now well established in their own careers. The names that I remember most (in alphabetical order) are: Abba Ansah, Katherine Ball, Geoff Black, Ryan Bruno, Hassan Chilmeran, Ridha Chilmeran, Eric Eastman, Ken Gilmour, Clay Greene, Indra Hardeen, Ryan Harder, Aaron Janzen (at the University of Calgary), Jamie Jiang, Mathew Chang Kit, Ryan Kwan, Soomin (Tomy) Lee, Tony Lipiec, Roelof Makken, Michael Patterson, Jeff Pelletier, Sasha Radulovich, Angela Ragoonath, Noureen Shah, Amar Shangavi, Peter Simcisko, Rajiv Singh, Harvey Stevens, Mireille Trent, and Klemen Zumer. They all cut their "research" teeth in my lab but gave much of their time and effort, and are now my friends. While some are completing Ph.Ds, others are well advanced in their professional careers; one of them (Roelof Makken) generously established the 'Mohammed Dore Graduate Research Scholarship' at Brock University and is now an adjunct Professor at Brock University, where he has taken over some of my teaching. Jamie Jiang in particular has taken on much of the econometric estimation work as well as the editorial work of these two books. Her work is meticulous and painstaking; she left my lab in the Fall of this year to start her Ph.D program. I think of all of my former students as my co-authors of these two books; I cannot imagine how I would have functioned without them.

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[1] Now transformed by the Federal Government into the "Canadian Climate Forum," it is no longer a granting agency.

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I wish to express my thanks to all of the people mentioned above for their help. But I alone am responsible for the contents of this book and for any remaining deficiencies.

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