

Delivering Sustainable Infrastructure

Sustainable Water

Edited by Charles Ainger and Richard Fenner



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Foreword

In many parts of the world the availability of fresh water is taken for granted. Few of us are aware that the vast majority of global water is sea water; unpolluted fresh water accounts for only 0.025% of total water accessible globally. An increasing population and a changing climate could increase demand for fresh water by 30% before 2030. Already parts of the world are using water unsustainably.

Our relationship with water is complex, with competing demands from a range of sectors. In particular, the trilemma between water, food and energy is an example of where resources are being stretched both globally and at a local scale. In the east of England – the UK's driest region – water is needed not only for a growing population but also for serving agriculture and protecting the environment. A changing climate is bringing us hotter and drier summers, warmer winters and, to test us even further, extreme weather events such as more intense storms. The warming of the oceans will lead to rising sea levels (typically by up to 320 mm by 2050), which could mean that some geographical areas will be below sea level, increasing the risk of catastrophic flooding from tidal surge events.

In Anglian Water we have taken a leadership position in response to these environmental challenges, for example by reducing capital and operational carbon with respect to building and operating our assets. Key to this is having a clear vision and leaders who can show us how we can mitigate the impacts of climate change.

Understanding all these challenges has a causal link to how we plan and construct our infrastructure both now and in the future. We have an opportunity to deliver sustainable solutions with reduced carbon, with less waste and at a lower cost; while being aware of stakeholder needs and preferences.

Our experience in tackling these challenges recognises the importance of leadership and vision across the full value chain. We require processes that demand and reward sustainable solutions, using innovation as the engine of change.

We are heading further into a resource-constrained future. The key messages and actions we need to take in the water sector are made clear through this book, helping us create a more sustainable world to meet the needs of future generations. The challenges that need to be faced are set out clearly at the beginning of the book,

and this is followed by a series of chapters that give practical and accessible guidance on what can be done to address the challenges at each stage of the delivery of water assets and services. The contrasting approaches that need to be taken in dealing with water issues in developing countries are covered in Chapter 10. The book concludes with suggestions of how change can be achieved through embracing innovation and challenging conventional ways of thinking, and these are illustrated with many examples of where this is already being done.

I would like to take the opportunity to thank both Charles and Dick and the many other expert contributors for writing this excellent book, and the series as a whole, and in helping to raise awareness of the principles of sustainability in action. This is not another textbook on the technologies of water systems. The value of this book lies in the wealth of advice as to 'what practitioners can do', at the level of everyday engineering decision-making in the water sector, and it will be an invaluable source of ideas for all those working in our industry.

Chris Newsome

Chair of UK Water Industry Research
Member of the Green Construction Board
Chair of the Infrastructure Working Group
Director of the Institute of Asset Management
Director of Asset Management, Anglian Water Services Ltd
Chairman of @one Alliance

Series introduction

The books in this series are engineering books about sustainability – not the other way round. They are for practising engineers, and other infrastructure professionals, who know generally of the challenges of sustainability but have not read specialist books on the subject. The books are accessible and focused, and are illustrated with case study examples. They will help the reader to understand sustainability, to identify and apply the critical changes needed in each infrastructure sector to provide more sustainable solutions, and to embed these into our engineering excellence tradition of delivering high-quality infrastructure on time, within cost and with good service – as quickly and straightforwardly as possible.

Asking the right questions at the right time

Many engineers start work in the later stages of project delivery: feasibility, project detailed design, construction or operation. They may find it difficult to see how, and when, the sometimes vague language of sustainability affects what they do. But engineers do have responsibility, and it matters because every infrastructure project contributes to, or detracts from, sustainability. As their careers progress, they may get involved in the earlier stages of projects – project scoping, or business strategy and objectives – where they can have a wider influence. Whatever stage an engineer is working in there are opportunities to deliver more sustainable solutions but, as value management tells us, the biggest opportunities are often in the earlier stages of the process and at the very start of each stage. Do not underestimate the difference that can be made even in the later stages: the best opportunities to deliver more sustainable infrastructure projects come by asking radical questions right at the start of each stage, before the pressure of ‘just get it done’ production takes over.

Each book in this series, whether it be on buildings, water, transport or other forms of infrastructure, refers to the key principles set out in the first book: *Sustainable Infrastructure: Principles into Practice*. The sector-specific books ask how these principles can be applied to particular types of infrastructure, highlight with examples where the principles are relevant, and ask ‘What can practitioners do?’. They provide a summary of the core sustainability challenges each infrastructure sector faces, and focus on emerging good sustainable practice drawn from expert practitioners in each field. They give practical advice on ‘how to do it’ and describe

opportunities where sustainable solutions can be introduced.

The books cover only the sustainability aspects of infrastructure, so are to be used alongside standard engineering texts and methods. The aim is not for the books to offer complete coverage, nor to be ‘balanced’; rather, they focus on things that most need changing and will make the most difference, using latest best practice – to help engineers deliver sustainable infrastructure.

Charles Ainger and Richard Fenner

Series editors

September 2015

About the series editors

Richard Fenner BSc(Hons), PhD, CEng, FCIWEM, MICE is a Reader in Engineering Sustainability in the Department of Engineering at Cambridge University and has published more than 100 papers, books and chapters. He is a Chartered Civil Engineer and Fellow of the Chartered Institution of Water and Environmental Management, specialising in water, sanitation and sustainability issues in developed and developing countries, with a focus on urban drainage and water industry asset management. He is the recipient of several awards from the ICE including the RA Carr prize and the James Watt Medal.

Charles Ainger MA, MSc, CEng, FICE, CIWEM is a former Sustainable Development Director for MWH's UK operations. He has extensive water and environmental engineering experience in 16 countries, from Europe to Asia. His particular interest is in facilitating effective innovation and change leadership in organisations moving to a more sustainable and carbon-neutral approach. He is a recipient of an ICE President's Medal.

Richard and Charles are joint winners of the ICE George Stephenson Gold Medal for the second best paper overall in the *Proceedings of the Institution of Civil Engineers*. The title of the paper is: ‘Widening engineering horizons: addressing the complexity of sustainable development’, and it is intended to help practising civil engineers answer the question ‘Am I being sustainable?’ during different phases of project delivery.

About this book

Background and purpose

We see a considerable gap in understanding and language between the concept of sustainability and the practice for actually achieving it in infrastructure. While many books have been published about sustainability in many aspects of water, few of them have approached it from the time-limited, output-driven perspective of the practical engineer/practitioner. This book series – *Delivering Sustainable Infrastructure* – aims to fill that gap. It applies a common set of sustainability principles to practice in different infrastructure sectors. The series so far has covered water, buildings, transport and waste management, and more volumes may be added. Each volume takes a similar approach, and applies the common set of principles and practice that was developed in the first, overarching book in this series, *Principles into Practice*.

This book

This is the sector book on water. It identifies the key issues facing the sector, and shows how these can be addressed in everyday practice by applying the common set of principles developed through the series. The book is for water-sector practitioners – all the varied professionals (and others) who play vital roles in creating and maintaining water-related services, including, of course, engineers – who know generally about the challenges of sustainability but have not studied the subject. The aim is to help the reader understand sustainability as it applies to water, and to identify and apply the critical changes needed to provide more sustainable solutions. We need to embed these changes in our tradition of service excellence – delivering water where it is needed, protecting the environment from pollution, and dealing with drainage and flooding – as straightforwardly as possible.

The book combines practical experience with academic rigour presented in a practical style. Several of the chapters have been written by authors who are specialists in their respective fields, and they have used a wide range of case studies and examples. For simplicity, we have used ‘practitioner’ as shorthand for all those who act in providing water services, including the many who are not engineers.

We do not intend to cover the fundamental technical knowledge needed for the design and operation of water systems, as such material can be found in many other

excellent books on water and wastewater engineering. Instead we explore which parts of these systems need to be challenged and new and more sustainable ways found for providing these essential water services. Throughout, we try and give examples of best practice where this can, and *is*, being done.

Book structure

This book is divided into three parts.

Part I: Principles introduces the key sustainability issues and challenges for the water sector, and summarises the book content (Chapter 1). It applies the core sustainability principles developed in *Principles into Practice* to the water sector, and thus identifies the sector priorities for change to sustainability (Chapter 2).

Part II: Practice is structured to match the priority areas for change that emerge from Chapter 2. In the pursuit of clarity and a strong focus, it does not attempt to give a complete coverage of the sector, and some compromise in chapter structure is involved. Chapters are broadly divided between the two stages of ‘planning’ and ‘service delivery’, to help you focus on the right questions at the right time:

- **Planning:** Chapter 3 – Water resources; Chapter 4 – Water in the urban system; Chapter 5 – Water in the rural system.
- **Service delivery:** Chapter 6 – Water demand and supply; Chapter 7 – Wastewater management; Chapter 8 – Drainage and flood resilience; Chapter 9 – Innovating beyond operations – a water company example; Chapter 10 – Water in development.

Each chapter, written by a practitioner who is specialist in the field, describes opportunities and methodologies for achieving water sector sustainability. All these authors draw on their own experience to illustrate leading-edge practice and collectively they provide a diverse range of viewpoints.

Part III: Change helps you to see *how* and *when* you can move companies, teams and projects to adopt that best practice. It discusses the drivers, barriers, potential ways to innovate, and how to influence by asking the right questions at the right time, and methodologies for developing sustainable solutions (Chapter 11). It then highlights four key trends that can enable innovation, with case study examples, and how they can work

together (Chapter 12). It finishes with an end note suggesting a 'direction of travel' towards a sustainable water sector, as an inspiration and goal for action (Chapter 13).

Finally, Appendix 1 summarises for reference the key principles from *Principles into Practice*, and Appendix 2 offers advice on how you can rapidly share new practice for sustainable water – a key to speeding up innovation.

This sector book makes many references to *Principles into Practice*, the general book that introduced the series. We hope you will read that too, but the aim is for the present book to stand on its own. The structuring of Part II around the separate subsectors of water will allow those of you with limited time to focus on those chapters that are most immediately relevant to your role. But start by reading Part I, to make sense of everything that follows. You can then dip into Part III to look for further help in whatever innovative action you want to try.

Some of this may seem hard to do, given present roles and practices, but there are such opportunities and they are already being exploited as best practice. If you know *what* questions to ask, and *when*, innovating towards sustainability is doable, even if you do not see yourself as a 'change agent'. You have more capacity to change things than perhaps you think. We can all, in effect, incorporate sustainability in our definition of 'good water engineering'.

This book will help you choose the *what*, *how* and *when*. We hope you will use it, enjoy it and feed your own innovative experience into the common store of water-sector knowledge about sustainability.

About the contributors

Richard Ashley

Richard is a professional civil engineer. He is Director of EcoFutures Ltd, and has some 50 years' experience in urban drainage, both in practice and as an academic. He is Emeritus Professor of Urban Water at the University of Sheffield in the UK, Adjunct Professor at Lulea Technical University in Sweden and Professor of Flood Resilience at UNESCO IHE in Delft, in the Netherlands. He was the recipient of the (IWA/IAHR) Joint Committee on Urban Drainage triennial Career Achievement Award in 2014 and for research into sustainable water systems in 2008. He has more than 500 publications, and advises governments, the OECD and international institutions on urban water, flooding and water-sensitive urban design. He is currently working on a water-sensitive city project in Australia, an EU blue-green URBAN project and several CIRIA projects.

David Balmforth

David is an Executive Technical Director with the international engineering company MWH, which he joined in 1999. He is an accomplished civil engineer specialising in flood risk management and urban pollution control. Formally an academic, his recent work ranges from the delivery of multi-million pound engineering programmes to flood advisory work for municipalities in the UK and overseas. He has acted as an advisor to governments on infrastructure development, and has recently worked to alleviate flooding in London, Glasgow and Singapore. His novel approaches to managing urban river pollution have been widely adopted and he has exhibited at the Design Centre in London. Formally a non-executive director of the Construction Industry Research and Information Association and Editor of the *Journal of Flood Risk Management*, David is now a visiting professor at Imperial College, London, and was President of the Institution of Civil Engineers from November 2014 to November 2015.

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As Deputy Director at the Environment Agency, Trevor's responsibilities include regulatory oversight for the management, operation and delivery of water resources across England. Specific responsibilities include access and allocation of water across sectors, strategic water resource planning, securing sustainable catchments, climate-change adaptation/mitigation, water competition/upstream markets, water demand management and

monitoring. Trevor's work also involves providing advice to government on water-management issues such as drought and longer-term pressures such as climate change.

Prior to his current role, Trevor worked for over 10 years in the water industry with a wide range of both strategic and operational roles in a number of water companies. Trevor's final role before joining the Environment Agency was Head of Regulation and Asset Performance at Mid Kent Water, with other areas of responsibility including customer services, incident management, networks and leakage. Trevor has also held the position of Director and Chairman of the Kent Biological Records Centre, as well as a range of roles on national committees and boards related to professional bodies. Before joining the water industry, Trevor worked as a consultant and a geologist in the oil industry.

Richard Burns

A chemist by training, an environmental manager by persuasion, Richard studied chemistry at Manchester before becoming a Senior Pollution Officer with Yorkshire Water Authority. He pursued his career in environment, safety and sustainability with Du Pont Howson, GSK and BOC before joining the world's leading water company, Veolia Water, in 2001. In his role as Director of Scientific and Corporate Responsibility Services Richard led a team of over 100 scientists, engineers and specialists in water quality, safety, environment, quality assurance, education, research and development, communications and internal audit.

On leaving Veolia in 2012, as founding Managing Director Richard set up EcoKIS Ltd, a consultancy advising companies and institutions in environment, health and safety, sustainability, research and development, marketing and business development. He was Visiting Professor at the Centre for Environmental Strategy at the University of Surrey.

Richard Carter

Richard has built up extensive knowledge of the natural and social science, engineering and management of water resources over a 40-year career. He has focused especially on groundwater development and management, rural water supply and sanitation, and water conservation and irrigation for food security. He manages institutional development and capacity-building activities,

consultancies, research projects, and education and training programmes in many aspects of the water sector. He has acted as adviser to numerous NGOs, UN agencies, bilateral and multilateral agencies, and has supervised many successful MSc and PhD students. Richard has worked in Afghanistan, Algeria, Bangladesh, Burkina Faso, Canada, DRC, Eritrea, Ethiopia, France, Honduras, India, Italy, Ivory Coast, Japan, Liberia, Madagascar, Malawi, Mali, Malaysia, the Netherlands, Niger, Nigeria, Pakistan, Rwanda, Sierra Leone, South Africa, Sri Lanka, Swaziland, Switzerland, Tanzania, Timor-Leste, Uganda, Zambia and Zimbabwe. He has published widely in the field of water resources management in low-income countries.

Adrian Johnson

Adrian is a Chartered Civil Engineer with 23 years' professional experience, mainly in the water sector, specialising in sustainable development, climate change and carbon management. He has supported various water company delivery programmes, and has led numerous consultancy and research commissions in developing and implementing plans, processes and tools on topics ranging from carbon accounting, resource efficiency, sustainable wastewater management and renewable energy appraisal to strategic environment assessment, climate change adaptation and flood resilience.

Adrian is a Technical Director for Sustainability at MWH. Since 2014, he has been working in Thames Water's capital delivery alliance, eight2O, advocating sustainable solutions to maximise efficiency, minimise carbon emissions, improve operational resilience and enhance benefits for Thames Water's customers and the environment.

Adrian is also an Honorary Professor at Heriot-Watt University, Edinburgh, and, as a Fellow of the Institution of Civil Engineers, has served on steering groups for two of its State of the Nation Reports and Low Carbon Panel. Adrian led the development of UKWIR's whole-life carbon guidelines and chaired a Technical Advisory Panel for the development of a BSI Publicly Available Specification (PAS 2080) on carbon management for the Green Construction Board.

Steve Kaye

Steve is a chartered mechanical engineer and has worked in the water industry for over 20 years. He is currently

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Steve's career began in the manufacturing industry, where he was involved in the research, design and manufacture of water networks technology. At Anglian Water, Steve played a key role in delivering major capital projects in water and water recycling, followed by a period as a regional operations manager in water recycling; he is currently the Head of Innovation.

Other posts Steve has held include Chair of the Industrial Advisory Group at Cranfield University and Leader of the European WssTP water and the energy nexus task force; he is currently Chairman of the STREAM programme (a collaboration between five UK universities supporting water-related engineering doctoral projects).

Steve is a creative individual who is passionate about making a better world through innovation.

Martin Ross

Martin is a director of his own consultancy business, Rainstorms Devon Ltd. He was formerly South West Water's Environmental Manager and developed the company's catchment management programme, Upstream Thinking, with the support of a number of environmental organisations based in the southwest of England. Upstream Thinking provides grants to improve farms and is restoring formerly drained and damaged peat uplands in the South West. The work is supported by research that is providing the scientific proof that catchment management is a successful and sustainable approach to protecting water-company assets, their performance and customer service. Upstream Thinking has the support of Ofwat, the Environment Agency, Natural England, the Drinking Water Inspectorate and others.

Previously, Martin undertook a range of responsibilities at South West Water and, before 1989, for South West Water Authority. These included capital investment, development of asset-management plans, investment planning and regulation. Other work was for clients, consultants and contractors in the UK and overseas. Martin is a graduate of the University of Manchester Institute of Science and Technology.

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Charles and Dick's collaboration on this book followed their joint writing of the first book in the series, *Sustainable Infrastructure: Principles into Practice*. Since they both specialise in water engineering, it was natural to write in part, as well as edit, *Sustainable Water*. Below they thank the many individuals involved in developing and preparing this book:

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Writing chapters and editing the book took much time and attention away from our families, and we thank our wives Judy and Gill for their forbearance. The book could not have happened without their love and support.

Dedication

This book is dedicated to all water practitioners, everywhere, who are helping to make water services sustainable, and particularly to those who are actively sharing their innovation experience.

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