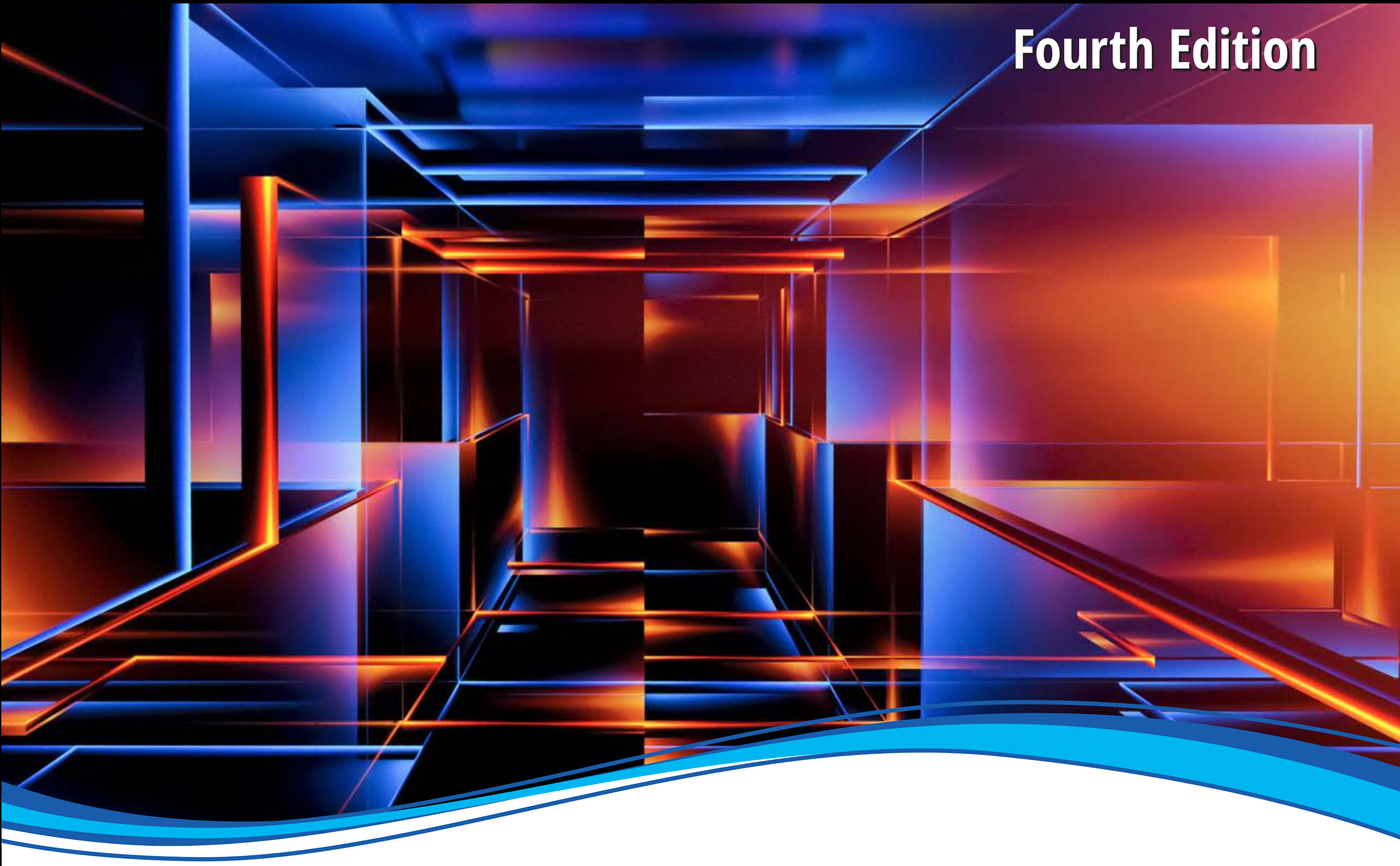
Manual of Water Supply Practices

# M32

# Computer Modeling of Water Distribution Systems



## Fourth Edition

American Water Works Association

This is a preview of "AWWA M32-2017". Click here to purchase the full version from the ANSI store.

Manual of Water Supply Practices

M32

# Computer Modeling of Water Distribution Systems

## Fourth Edition

American Water Works Association

Copyright © 2017 American Water Works Association. All Rights Reserved.

This is a preview of "AWWA M32-2017". Click here to purchase the full version from the ANSI store.

Manual of Water Supply Practices—M32, Fourth Edition

# Computer Modeling of Water Distribution Systems

Copyright © 2017 American Water Works Association

All rights reserved. No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopy, recording, or any information or retrieval system, except in the form of brief excerpts or quotations for review purposes, without the written permission of the publisher.

**Disclaimer**

The authors, contributors, editors, and publisher do not assume responsibility for the validity of the content or any consequences of its use. In no event will AWWA be liable for direct, indirect, special, incidental, or consequential damages arising out of the use of information presented in this book. In particular, AWWA will not be responsible for any costs, including, but not limited to, those incurred as a result of lost revenue. In no event shall AWWA's liability exceed the amount paid for the purchase of this book.

If you find errors in this manual, please email books@awwa.org. Possible errata will be posted at www.awwa.org/resources-tools/resource.development.groups/manuals-program.aspx.

Senior Managing Editor/Project Manager: Melissa Valentine
Cover art: Melanie Yamamoto
Production: Janice Benight
Manual Specialist: Sue Bach

---

**Library of Congress Cataloging-in-Publication Data**

Names: Cooper, James P., author. | Robinson, Laredo. Computer modeling of water distribution systems. | American Water Works Association, issuing body.
Title: M32 computer modeling of water distribution systems / by James P. Cooper.
Other titles: Computer modeling of water distribution systems
Description: Fourth edition. | Denver, CO : American Water Works Association, [2018] | Revised edition of: Computer modeling of water distribution systems / by Laredo Robinson, Jerry A. Edwards, Lindle D. Willnow. | Includes bibliographical references and index.
Identifiers: LCCN 2017049002 | ISBN 9781625762528 (alk. paper)
Subjects: LCSH: Water--Distribution--Data processing. | Network analysis (Planning)--Data processing.
Classification: LCC TD481 .C66 2018 | DDC 628.1/440285--dc23 LC record available at https://lccn.loc.gov/2017049002

Printed in the United States of America

ISBN-13 978-1-62576-252-8
eISBN-13 978-1-61300-439-5

*This AWWA content is the product of thousands of hours of work by your fellow water professionals. Revenue from the sales of this AWWA material supports ongoing product development. Unauthorized distribution, either electronic or photocopied, is illegal and hinders AWWA's mission to support the water community.*

American Water Works Association

American Water Works Association
6666 West Quincy Avenue
Denver, CO 80235-3098
awwa.org

This is a preview of "AWWA M32-2017". Click here to purchase the full version from the ANSI store.

# Contents

**Acknowledgments, xiii**

**List of Figures, vii**

**List of Tables, xi**

**Chapter 1 Introduction to Distribution System Modeling .......... 1**
- 1.1. Introduction, 1
- 1.2. Purpose of This Manual, 2
- 1.3. Historical Development of Distribution System Modeling, 3
- 1.4. Distribution System Modeling Applications, 5
- 1.5. Hydraulic Models, 8
- 1.6. Trends, 12
- 1.7. Summary, 13
- 1.8. Additional Resources, 14

**Chapter 2 Building and Preparing the Model .......... 17**
- 2.1. Introduction, 17
- 2.2. Planning the Hydraulic Model Construction and Development Process, 19
- 2.3. Data Sources and Availability, 23
- 2.4. Physical Facilities Development, 30
- 2.5. Demand Development, 46
- 2.6. Operational Data, 54
- 2.7. References, 58
- 2.8. Additional Resources, 58

**Chapter 3 Hydraulic Tests and Measurements .......... 61**
- 3.1. Introduction, 61
- 3.2. Field Testing—Planning and Preparation, 62
- 3.3. Water Distribution System Measurements, 69
- 3.4. Water Distribution System Testing, 79
- 3.5. Data Quality, 87
- 3.6. References, 88

**Chapter 4 Hydraulic Calibration .......... 91**
- 4.1. Introduction, 91
- 4.2. What Is Calibration?, 91
- 4.3. Steady-State Calibration, 102
- 4.4. EPS Calibration, 105
- 4.5. References, 110
- 4.6. Additional Resources, 110

**Chapter 5 Steady–State Simulation .......... 113**
- 5.1. Introduction, 113
- 5.2. System Performance Analyses, 114
- 5.3. System Design Criteria, 118
- 5.4. Developing System Improvements, 127
- 5.5. References, 129
- 5.6. Additional Resources, 130

Copyright © 2017 American Water Works Association. All Rights Reserved.

This is a preview of "AWWA M32-2017". Click here to purchase the full version from the ANSI store.

**Chapter 6 Extended-Period Simulation............131**
6.1. Introduction, 131
6.2. Extended-Period Simulation Basics, 133
6.3. Extended-Period Simulation Setup, 137
6.4. SCADA Information, 142
6.5. Modeling Controls, 145
6.6. Extended-Period Model Calibration, 147
6.7. System Evaluations With Extended-Period Simulations, 149
6.8. Special Types of Extended-Period Simulation Analyses, 156
6.9. Additional Resources, 159

**Chapter 7 Water Quality Modeling............161**
7.1. Introduction, 161
7.2. Need for Water Quality Modeling, 162
7.3. Uses of Water Quality Modeling, 162
7.4. Water Quality Modeling Techniques, 163
7.5. Governing Principles of Water Quality Modeling, 164
7.6. Reactions Within Pipes and Storage Tanks, 165
7.7. Computational Methods, 166
7.8. Data Requirements, 166
7.9. Modeling of Multiple Species, 170
7.10. Objectives of Water Quality Testing and Monitoring, 171
7.11. Monitoring and Sampling Principles, 171
7.12. Water Quality Surveys, 173
7.13. Use of Historical Data, 177
7.14. Tracer Studies, 177
7.15. Tank and Reservoir Field Studies, 181
7.16. Laboratory Kinetic Studies, 182
7.17. Water Quality Modeling and Testing Case Study, 183
7.18. References, 189

**Chapter 8 Storage Tank Mixing and Water Age............191**
8.1. Introduction, 191
8.2. Types of Tanks and Reservoirs, 192
8.3. Background, 192
8.4. Factors That Affect Water Quality in Tanks, 193
8.5. Types of Tank Modeling, 195
8.6. Tank Model Verification, 202
8.7. Strategies to Promote Mixing and Reduce Water Age, 202
8.8. References, 206

**Chapter 9 Model Maintenance............207**
9.1. Introduction, 207
9.2. Reasons for Model Maintenance, 208
9.3. Model Maintenance Plan, 210
9.4. Model Update Frequency, 212
9.5. Change Notification, 215
9.6. Data Source Integration, 217
9.7. Automated Model Update, 219
9.8. Return on Investment in Modeling, 220
9.9. Case Studies, 223

Copyright © 2017 American Water Works Association. All Rights Reserved.

This is a preview of "AWWA M32-2017". Click here to purchase the full version from the ANSI store.

**Chapter 10 Transient Analysis ........ 233**
10.1. Synopsis, 233
10.2. Introduction, 234
10.3. Causes of Transients, 236
10.4. Basic Pressure Wave Relations, 245
10.5. Governing Equations, 254
10.6. Numerical Solutions of Transients, 255
10.7. Methods for Controlling Transients, 255
10.8. Transient Modeling Considerations, 261
10.9. Transient Model Input Data Requirements, 263
10.10. Transient Model Calibration, 266
10.11. Summary, 267
10.12. Glossary of Notations, 268
10.13. References, 269

**Chapter 11 Advanced Modeling Applications ........ 273**
11.1. Introduction, 273
11.2. Reliability and Criticality, 273
11.3. System Rehabilitation and Prioritization, 274
11.4. Pump Energy Management, 275
11.5. Pressure Zone Management, 275
11.6. Flushing, 276
11.7. Nonrevenue Water and District Meter Areas, 277
11.8. Real-Time Modeling, 278
11.9. Optimization for Planning and System Operations, 279
11.10. References, 281
11.11. Additional Resources, 281

**Index, 283**

**List of Manuals, 293**

Copyright © 2017 American Water Works Association. All Rights Reserved.

This is a preview of "AWWA M32-2017". Click here to purchase the full version from the ANSI store.

This page intentionally blank.

Copyright © 2017 American Water Works Association. All Rights Reserved.

This is a preview of "AWWA M32-2017". Click here to purchase the full version from the ANSI store.

# Figures

Figure 1-1 Overview of an example modeling process , 3

Figure 2-1 Basic model structures, 21
Figure 2-2 Moody diagram, 36
Figure 2-3 Geographic information system detail versus model detail, 38
Figure 2-4 Pump head characteristic curve, 39
Figure 2-5 Nodes in close proximity, 43
Figure 2-6 Pipe-split candidates, 44
Figure 2-7 Intersecting pipes (Note: Confirm pipes are connected), 44
Figure 2-8 Disconnected or orphan nodes, 45
Figure 2-9 Parallel pipes, 45
Figure 2-10 Disconnected pipes, 45
Figure 2-11 An example diurnal curve, 54

Figure 3-1 Site-specific map of planned fire flow test, 64
Figure 3-2 Field log of pressure recorder during a flow test, 65
Figure 3-3 Example fire flow test report, 66
Figure 3-4 Hydrant testing public notification sign, 69
Figure 3-5 Secured pressure-recording device on a hydrant, 69
Figure 3-6 Chart of pressure logger system pressures, 70
Figure 3-7 Hand-held Pitot gauge, 71
Figure 3-8 Hand-held Pitot gauge in use, 72
Figure 3-9 Three general types of hydrant outlets: (A) 0.9 for round and smooth, (B) 0.8 for sharp and square, and (C) 0.7 for ports that protrude into the hydrant barrel, 72
Figure 3-10 Dechlorinating diffuser with manufacturer-supplied gauge, 73
Figure 3-11 Diffuser with pressure logger, 73
Figure 3-12 Traverse positions within a pipe with varying velocities, 74
Figure 3-13 Typical velocity profiles at two gauging points, 74
Figure 3-14 Schematic of a strap-on flowmeter, 76
Figure 3-15 Schematic of propeller flowmeter and picture of turbine flowmeter, 76
Figure 3-16 Venturi tube in service, 76
Figure 3-17 Typical Venturi tube with manometer, 77
Figure 3-18 Magnetic meter, 78
Figure 3-19 Simplified fire flow test configuration, 80
Figure 3-20 Parallel hose method for measuring head loss, 83
Figure 3-21 Two-gauge method for measuring head loss, 83
Figure 3-22 Pump test results, 84

Copyright © 2017 American Water Works Association. All Rights Reserved.

This is a preview of "AWWA M32-2017". Click here to purchase the full version from the ANSI store.

Figure 3-23 Hydraulic gradient layout, 85
Figure 3-24 Hydraulic gradient test results, 86
Figure 3-25 Modified surplus street sign, directing flow into a catch basin, 87

Figure 4-1 Steady-state flow calibration, 104
Figure 4-2 Steady-state hydraulic grade line calibration, 105
Figure 4-3 Extended-period simulation hourly peaking factors, 107
Figure 4-4 Extended-period simulation water level calibration, 109

Figure 5-1 Pump rating curve versus system head curve, 122
Figure 5-2 Multiple pump rating curves, 123
Figure 5-3 Example pump efficiency curve, 123
Figure 5-4 Equalization storage requirements for maximum day conditions, 125
Figure 5-5 Storage allocation, 126
Figure 5-6 Types of storage and elevation, 127

Figure 6-1 Typical diurnal demand patterns for different use categories, 136
Figure 6-2 Depth–volume relationship for a spherical tank, 138
Figure 6-3 Using supervisory control and data acquisition data in extended-period simulation models, 144
Figure 6-4 Examples of controls in EPANET, 146
Figure 6-5 Examples of EPS calibration graphs: (A) pressure, (B) flow, (C) tank levels, 148
Figure 6-6 Example utility demands versus time, 151
Figure 6-7 System physical parameters for extended-period simulation analysis, 151
Figure 6-8 Example of storage versus production for existing conditions, case 1, 152
Figure 6-9 Example of storage versus production with new production from well new production, case 2, 152
Figure 6-10 Example of storage versus production with new production (well 3) and storage (tank 3), case 3, 153
Figure 6-11 Comparing modeled pump output against a pump curve, 155
Figure 6-12 Example of storage versus production with supply interruption and recovery, case 4, 156
Figure 6-13 Example of storage versus production with fire demand and recovery, case 5, 157

Figure 7-1 Illustration of water quality model equilibration, 167
Figure 7-2 Example results from thermistor study showing temperature variation in tank, 182
Figure 7-3 Protocol for chlorine decay bottle test, 183
Figure 7-4 Skeletonized representation of zone I of the North Marin Water District, 185
Figure 7-5 Comparison of observed and modeled sodium concentrations in the North Marin Water District system, 186

Copyright © 2017 American Water Works Association. All Rights Reserved.

This is a preview of "AWWA M32-2017". Click here to purchase the full version from the ANSI store.

Figure 7-6 Average percent of Stafford Lake water in the North Marin Water District system, 187
Figure 7-7 Comparison of observed and modeled chlorine residual in the North Marin Water District system, 188

Figure 8-1 Schematic representation of the types of empirical models, 197
Figure 8-2 Tank water age calculated using an empirical model assuming complete mixing, 198
Figure 8-3 Effect of thermal differences for a tall tank, 200
Figure 8-4 Effect of thermal differences for an elevated tank, 200
Figure 8-5 Effect of operational and design changes, 200
Figure 8-6 Water age distribution, 201
Figure 8-7 Flow paths in unbaffled and baffled storage tanks, 201

Figure 9-1 Overview of an example modeling process, 212
Figure 9-2 Geographic information system editing sessions, nodes, and pipe labels; mislabeling causes disconnects in the model, 225
Figure 9-3 Typical model update protocol, 225
Figure 9-4 Model update process, 226
Figure 9-5 Work flow process flowchart, 229
Figure 9-6 Example of the drawing review process, 230
Figure 9-7 Model representation of proposed water main, 231

Figure 10-1 Example of steady-state transition after a period of rapid transients, 237
Figure 10-2 Transient caused by pump shutdown, 239
Figure 10-3 Transient caused by pump startup, 240
Figure 10-4 Transient caused by rapid valve opening, 240
Figure 10-5 Transient caused by rapid valve closing, 240
Figure 10-6a Rupture caused by valve closure, 241
Figure 10-6b Damaged pump bowl, 241
Figure 10-6c Broken air admission valve, 241
Figure 10-7 Varying pipeline profiles, 243
Figure 10-8 Example network schematic of a potentially vulnerable system, 244
Figure 10-9 Pressure surge fluctuations (field measurements) following routine pump shutdown, 244
Figure 10-10 Pressure wave propagation in a pipe, 246
Figure 10-11 Effect of a pipe junction on a pressure wave, 249
Figure 10-12 Effect of a dead end on a pressure wave, 249
Figure 10-13 Effect of a reservoir on a pressure wave, 250
Figure 10-14 Condition at a control element before and after action, 251
Figure 10-15 Wave propagation in a pipe section considering friction, 252
Figure 10-16 Impact of friction factor method on transient modeling results , 253
Figure 10-17 Flywheels to be installed in a large pump station, 258

Copyright © 2017 American Water Works Association. All Rights Reserved.

This is a preview of "AWWA M32-2017". Click here to purchase the full version from the ANSI store.

Figure 10-18 Typical locations in a water distribution system for various surge-protection devices, 260
Figure 10-19 Flowchart for surge control in a water distribution system, 260
Figure 10-20 Representative valve closure characteristics, 265
Figure 10-21 Typical pump four-quadrant characteristics (the Suter curve), 265
Figure 10-22 Example of pressure logger recording at insufficient rate, 267

Figure 11-1 Conventional versus unidirectional flushing, 276
Figure 11-2 Example trade-off curve generated by a multiobjective optimization run, 280

Copyright © 2017 American Water Works Association. All Rights Reserved.

This is a preview of "AWWA M32-2017". Click here to purchase the full version from the ANSI store.

# Tables

Table 2-1 Pipe roughness Hazen–Williams *C*-factors for discrete pipe diameters, 33
Table 2-2 Equivalent sand grain roughness for various pipe materials for use in the Darcy–Weisbach equation, 34
Table 2-3 Typical minor loss coefficients, 37
Table 2-4 Operational data required by facility or equipment type, 55

Table 5-1 Typical model scenarios, 114

Table 8-1 Example modifications to improve tank mixing characteristics, 203

Table 9-1 AMWSC water sources, 227
Table 9-2 Water main installation summary, 228

Table 10-1 Physical properties of common pipe materials, 248

Copyright © 2017 American Water Works Association. All Rights Reserved.

This is a preview of "AWWA M32-2017". Click here to purchase the full version from the ANSI store.

This page intentionally blank.

Copyright © 2017 American Water Works Association. All Rights Reserved.

This is a preview of "AWWA M32-2017". Click here to purchase the full version from the ANSI store.

# Acknowledgments

The AWWA Engineering and Construction Division and the Technical and Educational Council acknowledge the following individuals for their persistence and dedication in developing the fourth edition of this manual:

Chair—James P. Cooper, P.E., *Arcadis, Akron, Ohio*

## Authors

### Chapter 1 Introduction to Distribution System Modeling

*Sharavan V. Govindan,* Bentley Systems Inc., Exton, Penn.
*Adam Simonsen,* IDModeling Inc., Waterbury, Conn.

### Chapter 2 Building and Preparing the Model

*Christie Patel, P.E.,* Brown and Caldwell, Philadelphia, Penn.
*Mike Rosh,* Bentley Systems Inc., Sayre, Penn.

### Chapter 3 Hydraulic Tests and Measurements

*James P. Cooper, P.E.,* Arcadis, Akron, Ohio
*Douglas Lane, P.E.,* City of Bellevue, Bellevue, Wash.

### Chapter 4 Hydraulic Calibration

*Douglas Harrold, P.E.,* City of Santa Clara Water and Sewer Utilities, Santa Clara, Calif.
*Saša Tomic´, P.E., Ph.D.,* HDR Engineering Inc., New York, N.Y.

### Chapter 5 Steady-State Simulation

*Paul Hsiung, P.E.,* Innovyze, Shawnee Mission, Kans.
*Amanda Schwerman, P.E.,* Black & Veatch, Tampa, Fla.

### Chapter 6 Extended-Period Simulation

*Patrick B. Moore, P.E.,* Innovyze, Edgewood, N.M.
*Lindle D. Willnow, P.E.,* AECOM, Wakefield, Mass.

### Chapter 7 Water Quality Modeling

*James P. Cooper, P.E.,* Arcadis, Akron, Ohio
*Megan G. Roberts, P.E.,* Hazen and Sawyer, P.C., Greensboro, N.C.

### Chapter 8 Storage Tank Mixing and Water Age

*Bob Hawboldt. P.E., Ph.D.,* Associated Engineering, Saskatoon, Sask.
*Ferdous Mahmood, P.E.,* Arcadis, Dallas, Texas

Copyright © 2017 American Water Works Association. All Rights Reserved.

This is a preview of "AWWA M32-2017". Click here to purchase the full version from the ANSI store.

### Chapter 9 Model Maintenance

*Jeff Cowburn,* City of Abbotsford, Abbotsford, B.C.
*Mike Rosh,* Bentley Systems Inc., Sayre, Penn.
*Saša Tomic´, P.E., Ph.D.*, HDR Engineering Inc., New York, N.Y.

### Chapter 10 Transient Analysis

*Ferdous Mahmood, P.E.,* Arcadis, Dallas, Texas
*Lindle D. Willnow, P.E.,* AECOM, Wakefield, Mass.

### Chapter 11 Advanced Modeling Applications

*Rajan Ray*, Innovyze, Wakefield, R.I.
*Adam Simonsen,* IDModeling Inc., Waterbury, Conn.
*Thomas M. Walski, Ph.D., P.E.*, Bentley Systems Inc., Nanticoke, Penn.

The authors would like to acknowledge the following individuals who provided editorial and technical comments and/or contributed in other ways:

*Paul F. Boulos, Ph.D.,* Innovyze, Broomfield, Colo.
*Jeff Cowburn,* City of Abbotsford, Abbotsford, B.C.
*Nass Diallo, P.E.*, Las Vegas Valley Water District, Las Vegas, Nev.
*Jerry A. Edwards, P.E.,* Bohannan Huston, Englewood, Colo.
*Jeff Frey, P.E.,* Optimatics, Chicago, Ill.
*Walter M. Grayman, P.E., Ph.D.*, W.M. Grayman Consulting Engineer, Cincinnati, Ohio
*Douglas Harrold, P.E.*, City of Santa Clara Water and Sewer Utilities, Santa Clara, Calif.
*Paul M. Hauffen,* IDModeling Inc., Arcadia, Calif.
*J. Erick Heath, P.E.*, Innovyze, Arcadia, Calif.
*Jonathan Keck*, California Water Service,
*Douglas Lane, P.E.,* City of Bellevue, Bellevue, Wash.
*Patrick B. Moore, P.E.*, Innovyze, Edgewood, NM.
*Myron Nealey, P.E.*, Denver Water, Denver, Colo.
*Christie Patel, P.E.*, Brown and Caldwell, Philadelphia, Penn.
*Theresa O'Grady, P.E.*, Crawford, Murphy & Tilly, Aurora, IL.
*Rajan Ray*, Innovyze, Wakefield, R.I.
*Jeffrey Rosenlund*, DOWL, Sheridan, Wyo.
*Mike Rosh,* Bentley Systems Inc., Sayre, Penn.
*Amanda Schwerman, P.E.,* Black & Veatch, Tampa, Fla.
*Jennifer Suttles, P.E.,* Hazen & Sawyer, Atlanta, Ga.
*Jim Uber,* CitiLogics, Covington, Ky.
*Bryon Wood, P.E.*, HDR Engineering, Inc., Ann Arbor, Mich
*Andy Yang,* San Jose Water Company, San Jose, Calif.
*Samual Ziemann*, C3 Water, Breslau, Ont.
*Jill Zimmerman,* Albemarle County Service Authority, Charlottesville, Va.

Copyright © 2017 American Water Works Association. All Rights Reserved.

This is a preview of "AWWA M32-2017". Click here to purchase the full version from the ANSI store.

The following individuals provided peer review of the entire manual. Their knowledge and efforts are gratefully appreciated:

*James P. Cooper, P.E.,* Arcadis, Akron, Ohio
*Theresa O'Grady, P.E.,* Crawford, Murphy & Tilly, Aurora, Ill.
*Patrick F. Parault, P.E.,* Arcadis, Long Island City, N.Y.
*Jennifer Santini,* American Water Works Association, Denver, Colo.
*Jim Siriano,* American Water Works Association, Denver, Colo.
*Saša Tomic´, P.E., Ph.D.*, HDR Engineering Inc., New York, N.Y.
*Thomas M. Walski, Ph.D., P.E.*, Bentley Systems Inc., Nanticoke, Penn.
*Lindle D. Willnow, P.E.,* AECOM, Wakefield, Mass.

Copyright © 2017 American Water Works Association. All Rights Reserved.

This is a preview of "AWWA M32-2017". Click here to purchase the full version from the ANSI store.

This page intentionally blank.

Copyright © 2017 American Water Works Association. All Rights Reserved.

This is a preview of "AWWA M32-2017". Click here to purchase the full version from the ANSI store.

## Chapter 1

# Introduction to Distribution System Modeling

## 1.1. INTRODUCTION

Water utilities seek to provide customers with a safe, reliable, continuous supply of high-quality drinking water while managing costs. This water is often delivered through a complex network of pipelines, numerous pumps, regulating valves, and storage reservoirs. The performance of these water systems is often difficult to measure and understand because of their physical size, complexity, underground location (out of sight, out of mind), and the large amount of system data needed to fully grasp how they function. Sometimes, key pieces of information needed to understand a system are missing or incomplete. One tool that has evolved over time to help water system designers, operators, planners, and managers meet their goals of delivering a safe, reliable, cost-effective water supply is a water distribution system model (herein referred to as a *model*).

Distribution system modeling (commonly referred to as *hydraulic modeling*) involves the use of a computerized mathematical model to predict the performance of a water system to solve a wide variety of issues including, but not limited to, design, operations, system planning, water quality, water loss, energy management, and emergency response. Models can help water utilities by enabling more proactive and responsive decision making, delivering better customer service, and ensuring employee satisfaction. Water utilities can use models to understand the infrastructure and operations needed to support a network of growing residential and commercial consumers. For example, a model can predict pressures and flows within a water system in order to evaluate a design and compare the system performance against design standards. Models are also used in operational studies to answer questions related to storage capacity, control schemes, water delivery, water

Copyright © 2017 American Water Works Association. All Rights Reserved.

This is a preview of "AWWA M32-2017". Click here to purchase the full version from the ANSI store.

quality, and more. Water quality models are used to predict water age, track disinfectant residuals, and reduce disinfection by-products in a distribution system.

Computerized system modeling began with the advent of analog computers and has evolved as software and hardware have advanced to become more powerful and easier to use. Models that contain hundreds or thousands of miles of pipeline are now common and can be used on a wide variety of computer platforms. Models that once took hours to run are now run in seconds or fractions of a second. Originally, models were used only to evaluate system hydraulic grade lines, system pressures, and flows.

Historically, model building was an expensive and labor-intensive process due to lack of available data to build from and to support relevant applications. Now, models can effectively share data with geographic information systems (GIS), computer-aided design and drafting (CADD) systems, supervisory control and data acquisition (SCADA) systems, customer information systems (CIS), computerized maintenance management systems (CMMS), and asset management system (AMS) software, thus reducing the effort needed to create, update, calibrate, and maintain a model. Information obtained from a model study can be filtered, organized, and presented using a variety of graphical and tabular methods so that results can be more easily understood and communicated. These advances in technology have broadened the uses of distribution system modeling from just an infrastructure planning tool to an integrated design-and-operations analysis system.

## 1.2. PURPOSE OF THIS MANUAL

The Engineering Modeling Applications Committee of the American Water Works Association developed this manual. The purpose of this manual is to share the committee's collective experience with distribution system modeling to help educate and communicate the benefits of a model to water utilities and water customers everywhere.

The manual is intended to be a basic-level or primer reference guide to provide new to intermediate modelers with a foundation for, and practical benefits of, water distribution system modeling. The manual takes users through the modeling process from development to system analysis as shown in Figure 1-1. The manual delivers in-depth discussion on

- Model construction and development,
- Field data collection and testing,
- Model calibration,
- Steady-state analysis,
- Extended-period simulation,
- Water quality analysis,
- Storage tank mixing and water age analysis,
- Model maintenance,
- Transient analysis, and
- Advanced modeling applications.

M32 is designed to help modelers use water models as effective tools to plan, design, and operate a water distribution system; maintain acceptable water quality; and reduce both operating costs and water loss within their water distribution systems.

Copyright © 2017 American Water Works Association. All Rights Reserved.