
Contents

Preface	xiii
Acknowledgments	xv
1 Introduction	1
1.1 Background	1
1.2 The Purpose of This Manual and Its Structure	2
References	3
2 Water Loss Control: A Topic of the Twenty-First Century	5
2.1 How Much Water Are We Losing?	5
2.2 The Need for Water and Basic Facts about the Resource Water	7
2.3 Historic Water Supply and Milestones in Water Loss Control	8
2.4 The Occurrence and Impact of Lost Water	9
2.5 Forces Driving Change in the Way Water Loss Is Viewed and Managed	10
2.6 What is Being Done Around the World to Reduce Lost Water?	11
2.7 Program Needs and Requirements for Water Loss Control ..	13
References	17
3 Understanding the Types of Water Losses	19
3.1 Defining Water Supplier Losses	19
3.2 Conclusion	29
References	29
4 Water Loss Management in the United States and Internationally—What is Necessary to Control the Water Loss Problem?	31
4.1 Introduction	31
4.2 Water Loss Management in the United States	32
4.3 International Leakage Management	40
4.4 The Need for Meaningful Regulations	46
4.5 Summary	47
References	49
5 Steps and Components of a Water Loss Control Program	51
5.1 Introduction	51
5.2 Top-Down and Bottom-Up Water Loss Assessment— How Much Water Are We Losing and Where?	51
5.3 Determine the Economic Optimum for Your Water Losses	55

5.4	Design the Right Intervention Program	56
5.5	Implementation Phase	58
5.6	Evaluate the Results	58
5.7	Examples of Water Loss Control Program Costs in North America	58
5.8	Conclusion	59
	Reference	59
6	Validation of Source Meter Accuracy	61
6.1	The Importance of Source Meter Accuracy to the Integrity of the Water Audit and Loss Control Program	61
6.2	Key Source Meter Sites for Proper Flow Balancing	62
6.3	Types of Source Meters	68
6.4	Source Meter Accuracy and Testing Program Steps	70
6.5	What to Do if Meters Do Not Exist at Key Metering Sites	73
6.6	Summary: Source Meter Accuracy	73
	References	74
7	Evaluating Water Losses—Using a Standardized Water Audit and Performance Indicators	75
7.1	Introduction	75
7.2	A Rosetta Stone for Water Loss Measurement	77
7.3	The Benefits of the IWA/AWWA Standard Water Audit and Performance Indicators	78
7.4	The IWA/AWWA Recommended Standard Water Audit	79
7.5	Unavoidable Annual Real Losses—Unavoidable Water Losses and Discovered Leaks and Overflows	83
7.6	Which Performance Indicator? What’s Wrong with Percentages?	87
7.7	IWA/AWWA Recommended Performance Indicators for Nonrevenue Water and Real Losses	89
7.8	The Use of 95% Confidence Limits and Variance Analysis for Water Audits	92
7.9	Conclusion	94
	References	94
8	Data Collection, Formatting, and Management	95
8.1	Introduction	95
8.2	Data Collection Worksheet	96
8.3	Data Calibration Form	100
8.4	Summary	100
9	Identifying Economic Interventions against Water Losses	103
9.1	Introduction	103
9.2	Definition	103
9.3	Short-Run ELL	105
9.4	Long Run ELL	108
9.5	Deficiency in Water Supply Reliability	112

9.6	History and Experience	115
9.7	Practical Application	116
9.8	Summary	117
References	.....	118
10	Modelling Water Losses	121
10.1	Introduction	121
10.2	Top-Down Water Audit Spreadsheet Models	122
10.3	Component Analysis and Modeling of Apparent Loss	128
10.4	Modeling Components of Real Losses Using Breaks and Background Estimates Concepts	133
10.5	Using BABE Modeling Concepts to Prioritize Activities	134
10.6	Modeling Background Losses	138
10.7	Summary	154
References	.....	154
11	Controlling Apparent Losses—Capturing Missing Revenue and Improving Consumption Data Integrity	155
11.1	Introduction	155
11.2	How Apparent Losses Occur	156
11.3	Customer Meter Inaccuracy	157
11.4	Data Transfer and Systematic Data-Handling Errors	158
11.5	Unauthorized Consumption	159
11.6	The Impacts of Apparent Losses	160
11.7	The Economic Approach to Apparent Loss Control	161
11.8	Developing a Revenue Protection Program to Control Apparent Losses	165
11.9	Apparent Loss Control: A Summary	168
References	.....	168
12	Controlling Apparent Losses—Customer Meter Inaccuracy	171
12.1	Customer Meter Function and Accuracy	171
12.2	Customer Meter Demographics and Consumption Record ...	172
12.3	Flow Measurement Capabilities of Customer Water Meters ...	174
12.4	Customer Meter Sizing	177
12.5	Developing the Customer Meter Accuracy Testing Program ...	181
References	.....	199
13	Controlling Apparent Losses from Data Transfer Errors by Leveraging Advanced Metering Infrastructure	201
13.1	The Customer Water Consumption Data Transfer Process	201
13.2	Customer Consumption Profiles—Transitioning from Periodic Customer Meter Readings to Granular Consumption Data	215
13.3	Summary: Apparent Loss from Data Transfer Error	224
References	.....	224

14	Controlling Apparent Losses from Systematic Data Handling Errors in Customer Billing Systems	225
14.1	Compiling Billed Consumption in Customer Billing Systems	225
14.2	Using the Customer Billing System to Extract Customer Water Consumption Data	229
14.3	Adjusting for Lag Time in Customer Meter Reading Data ...	230
14.4	Determining the Volume of Apparent Loss Due to Systematic Data Handling Error in Customer Billing Systems	233
14.5	Billing Policy and Procedure Shortcomings	240
14.6	Quantifying Systematic Data Handling Errors in the Water Audit and Addressing These Losses	245
15	Controlling Apparent Losses—Unauthorized Consumption	247
15.1	Unauthorized Consumption Occurs in Many Ways	247
15.2	Quantifying the Volume of Unauthorized Consumption in the Water Audit	248
15.3	Controlling Unauthorized Consumption	249
	References	257
16	Controlling Real Losses in the Field—Proactive Leak Detection	259
16.1	Introduction	259
16.2	Mapping	261
16.3	Leakage Fundamentals	265
16.4	Leak Detection Equipment	269
16.5	Leak Detection Techniques	275
16.6	Zoning and District Metered Areas	281
16.7	Testing for Reservoir Leakage	292
16.8	Summary	293
	References	293
17	Controlling Real Losses—Speed and Quality of Leak Repair	295
17.1	Introduction	295
17.2	Leak Runtime Reduction	295
17.3	Quality of Leak Repair	299
17.4	Summary	299
	Reference	299
18	Controlling Real Losses—Pressure Management	301
18.1	Introduction	301
18.2	Why Undertake Pressure Management Schemes?	302
18.3	Various Types of Pressure Management	307
18.4	Leakage Control—Pressure Leakage Theories	312
18.5	Overflow Control	314
18.6	Fundamental Monitoring Points	315
18.7	Flow Measurements	315
18.8	Pressure Measurements	316

18.9	Using Hydraulic Computer Models to Identify Ideal Locations for Installation	316
18.10	Understanding the Hydraulics of Your System Prior to Implementation	317
18.11	Using Statistical Models to Calculate the Potential Benefit of a Scheme	317
18.12	Calculating Cost to Benefit Ratios	317
18.13	How Do ACVs Work?	318
18.14	Pressure Reduction	319
18.15	Locating Installation Points in the Field	320
18.16	Multiple Valve Sectors	320
18.17	Reservoir and Tank Control	321
18.18	Valve Selection and Sizing	326
18.19	Using Controllers to Make Your Hydraulic Valves More Efficient	332
18.20	SCADA	334
18.21	Valve Installation	335
18.22	Maintenance Concerns	341
18.23	The Chamber	341
18.24	Nonhydraulic Pressure Control	341
18.25	Summary	343
	References	343
19	Controlling Real Losses—Infrastructure Management	345
19.1	Introduction	345
19.2	Pipeline Corrosion	346
19.3	Pipe Rehabilitation and Replacement	347
19.4	Summary	350
20	Water Efficiency Programs	351
20.1	Introduction	351
20.2	Why Plan a Water Efficiency Program	352
20.3	System Demand Components and How They Relate to a WEP	352
20.4	Water Saving Targets	359
20.5	Implementation Plan	362
20.6	Monitoring and Tracking	364
20.7	Lost Revenues	367
20.8	Conclusion	368
21	Using In-House Staff or a Contractor and Designing a Bid Document	369
21.1	Introduction	369
21.2	Using In-House Staff or a Contractor	369
21.3	Designing a Bid Document	371

21.4	Summary	378
21.5	Checklist	379
	Reference	379
22	Understanding Basic Hydraulics	381
22.1	Introduction	381
22.2	Pipe Roughness Coefficients	381
22.3	C-Factor Testing in the Field	382
22.4	Firefighting Regulations	383
22.5	Flow Terms	383
22.6	Pressure Terms	387
22.7	Summary	392
	References	392
A	Case Studies	393
B	Equipment & Techniques	533
C	Demand Profiling for Optimal Meter Sizing	589
	Glossary	607
	Index	615