Manual of Water Supply Practices

M5

Water Utility Management

Third Edition

American Water Works Association

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Water Utility Management, 2nd edition

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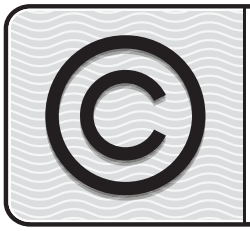

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Acronyms and Abbreviations

AMR/AMI	automated meter reading/advanced metering infrastructure
AMWA	Association of Metro Water Agencies
APD	alternative project delivery
APQC	American Productivity and Quality Center
ASP	Association for Strategic Planning
AWWA	American Water Works Association
BI	business intelligence
CAA	Clean Air Act
CCR	consumer confidence report (eCCR = electronic consumer confidence report)
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CIP	capital improvement plan
CIS	customer information system
CMMS/EAM	computerized maintenance management system/enterprise asset management
CPM	capital program management
CSO	combined sewer overflow
CSR	customer service representative
CUPSS	Check Up Program for Small Systems
CWA	Clean Water Act
CWSRF	Clean Water State Revolving Fund
DCS	distributed control system
DHS	Department of Homeland Security
DWSRF	Drinking Water State Revolving Fund
EPCRA	Emergency Planning and Community Right-to-Know Act
ERP	enterprise resource planning
ETA	Employment and Training Administration
EUM	effective utility management
FAQ	frequently asked question
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FIS	financial information system
GIS	geographic information system
HMI	human-machine interface
HSE	health, safety, and environment
ICS	Incident Command System
ICS-CERT	Industrial Control Systems Cyber Emergency Response Team
I/I	infiltration and inflow
IoE	Internet of Everything
IoT	Internet of Things
IT	information technology
IWA	International Water Assocation
KM	knowledge management
LIMS	laboratory information management system
LIS	laboratory information system

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LOS	levels of service
MCL	maximum contaminant level
NAAQS	National Ambient Air Quality Standards
NACWA	National Association of Clean Water Agencies
NCEES	National Council of Examiners for Engineering and Surveying
NIMS	National Incident Management System
NIST	National Institute of Standards and Technology
NPDES	National Pollutant Discharge Elimination System
ODMS	operations data management system
PC	personal computer
PLC	programmable logic controller
PM	preventive maintenance
POTW	publicly owned treatment works
RCM	reliability-centered maintenance
RCRA	Resources Conservation and Recovery Act
RFID	radio-frequency identification
ROI	return on investment
RTU	remote terminal unit
SaaS	software-as-a-service
SCADA	supervisory control and data acquisition
SDC	system development charge
SDWA	Safe Water Drinking Act
SIMPLE	Sustainable Infrastructure Management Program Learning Environment
SMART	specific measurable achievable relevant and time based
SSO	sanitary sewer overflow
TSCA	Toxic Substances Control Act
URI	Utility Resilience Index
US BLS	US Bureau of Labor Statistics
US DOL	US Department of Labor
USEPA	US Environment Protection Agency
UST	underground storage tank
VA	vulnerability assessment
WARN	Water and Wastewater Agency Response Network
WaterRF	Water Research Foundation
WEF	Water Environment Federation
WERF	Water Environmental Research Foundation
WIFA	Water Infrastructure Financing Authority

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Introduction

THE NEW M5: FACILITATING SUCCESS FOR WATER AND WASTEWATER UTILITY MANAGERS

Can you imagine a city without water and wastewater utilities? Imagine whole towns drinking untreated water. Can you imagine US households without access to functioning sewer systems? The simple truth is that our modern lives are built on the premise that we will have clean water and the ability to dispose of water 24 hours a day, every day of the year. The provision of water services is fundamental to us—a matter of public health.

North American water and wastewater managers are public health providers with unparalleled track records of success. Another simple truth—in the twentieth century alone, the applications of our industry's science, tools, and trades saved more lives than any other single health development. The people who design and manage our water processes are nothing less than heroes and our target readers of the updated M5. The M5 update is here to help water and wastewater utility managers stay heroes in the twenty-first century.

Today, increasing demands, changing technologies, uncertain costs, and aging systems complicate every utility manager's role. Whether a utility is large or small, successful utility management requires more than single-subject expertise. High expectations are placed on established managers to improve their range of functionality. M5 will help experienced managers in North America and elsewhere broaden their perspectives. Newly minted utility managers will find here a means to untangling today's multiple water–wastewater utility issues and to continue taking steps toward a fulfilling career.

A GO-TO REFERENCE FOR WHAT IS IMPORTANT TO YOU

Utility managers need a strategic process for establishing their vision, mission, and plan for achieving their most critical objectives. Chapter 3 is dedicated to utility strategy. Need a primer on performance measurement? See chapter 5. Where do you learn about establishing a cycle (a culture) of plan/do/check/act, and do that with an ethnically and educationally diverse workforce? Turn to chapter 4. Want to survey your employees in accord with the 10 attributes of the effective utility management (EUM) approach? Consider chapter 6. The updated M5 will help locate the best management resources.

This manual delivers approaches to the plans (and planning processes) that require more detail than overarching strategic planning. Managers also need to account for their specific responsibilities, which they may choose to do in a communication plan, a capital plan, a divisional business plan, and master planning of all varieties (see chapter 3). This update is designed as your road map to navigate the array of resources that are already available—in print, in electronic media, at conferences, and with peer utilities.

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UPDATING M5

AWWA's Strategic Management Practices Committee was tasked with updating M5. The committee began by studying the contemporary topics of water–wastewater utility managers, including workforce capability; fostering safety culture; managing assets and risk; the tricky balance of public support, scarce revenues, and aging infrastructure; and rapidly changing information management technology.

The committee built on the previous edition of M5, which documented the fundamentals of managing a utility from managing operations and maintenance to customer service, from communication to emergency planning, and from safety regulation to financial management. By focusing on the key contemporary topics of vital interest to water–wastewater managers, the committee has produced a new edition of M5 that goes beyond basic books on water–wastewater utility management. Additionally, the committee has included information on the vast resources that exist in AWWA on these well-established management topics. And it should be noted that books in the general management literature covering business strategy, leadership, and a variety of management techniques also have merit for utility managers. Finally, while the committee's experience and strengths were gained from a North American perspective, utility managers will benefit no matter where they are based.

Since the most recent M5 update, there has been increasing demand for water and wastewater utilities to focus on continuous improvement. Improvement programs may include self-assessment, outside assistance (peer review or consultancy), and benchmarking tools. QualServe was an early example of a continuous improvement system designed specifically for water and wastewater utilities. Involving self-assessment, peer review, and benchmarking, this program provided the foundation for *Effective Utility Management: A Primer for Water and Wastewater Utilities.*

The EUM *Primer* defines attributes common to all water and wastewater utilities, covering a range of desired utility outcomes in the areas of operations, infrastructure, customer satisfaction, community welfare, natural resource stewardship, and financial performance. These attributes have proven useful and concise reference points for utility managers seeking to improve organizationwide performance. They can best be viewed as a continuum of, or a set of building blocks for, management improvement opportunities and are referenced throughout M5.

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Chapter 1

Utility Management and Regulation

This chapter is a high-level review of the legal basis of regulation and management approaches. The purpose is to describe fundamental regulatory considerations faced by a water or wastewater utility manager.

Wastewater and drinking water utilities are driven by a mission to ensure public health through water management of all kinds. A manager's planning agenda is frequently dominated by working toward objectives associated with public health; compliance with legal obligations, including federal, state, and local; and environmental, health, and safety requirements. Failure to comply with many of these requirements may result in administrative, civil, and criminal penalties, in addition to unwanted attention from the media.

Utility managers are leaders of multitalented people out of necessity, because no one knows everything about water. Clean or dirty water management requires engineering, biological, chemical, design, financial, organizational, legal, and other subject matter expertise. Variations in regulatory requirements mean utility managers should have ready access to qualified professionals in nearly every field. Legal expertise is an important, even essential collaborating partner to a utility manager.

This manual is one of multiple resources of the American Water Works Association (AWWA) designed specifically for water and wastewater professionals. Importantly, AWWA creates standards addressing the entire industry spectrum of treatment plant operators and managers, scientists, environmentalists, manufacturers, academicians, regulators, and utilities. AWWA's published standards cover hundreds of products and procedures.

LOOKING FOR LAW IN ALL THE RIGHT PLACES

Environmental legal obligations are numerous and complex. These obligations exist at the federal, state, and local levels. The nature of the legal obligations imposed on utilities ranges from broad statutes to complex regulations or policies. The legal obligations address the relationship of the utility's operations to the health and safety of its employees and its impact on the environment. As a result, it is suggested that a leader of a water or

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wastewater utility have access to a qualified environmental attorney or, as necessary, an environmental regulatory professional. In consultation with a qualified environmental attorney, it is likely that a water or wastewater utility will better address environmental legal obligations and attempt to prevent, detect, or correct any violations alleged by federal, state, or local authorities.

Utility managers must possess a fundamental understanding of the major environmental legal obligations impacting utility operations. Depending on geographic location and size of operations, water and wastewater utilities' legal obligations to the variety of federal, state, or local environmental requirements may vary. These environmental legal obligations certainly include well-known statutory or regulatory provisions of the Safe Drinking Water Act (SDWA), which includes the provisions for National Pollutant Discharge Elimination System (NPDES). The NPDES addresses water pollution by regulating point sources that discharge pollutants to waters of the United States. This is a permit program authorizing state governments to perform many permitting, administrative, and enforcement aspects of the USEPA-administered program.

It should be recognized that many state and/or local environmental authorities have implemented and will enforce provisions either equal to or more stringent than those contained within the Clean Air Act (CAA), the Clean Water Act (CWA), the Resource Conservation and Recovery Act (RCRA), the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), the Emergency Planning and Community Right-to-Know Act (EPCRA), and the Toxic Substances Control Act (TSCA).

Drinking water and wastewater operation and treatment facilities are part of the utilities sector designated by the US Environmental Protection Agency (USEPA) in the North American Industry Classification System known as NAICS 22. Industries in this sector include water treatment plants, water supply systems, sewer systems, and/or sewage treatment facilities that collect, treat, and dispose of waste.

HISTORY IN YOUR LIFETIME

The Clean Water Act, a crucial law that protects the nation's water from pollution, was passed at a time when much of US water was so contaminated by industrial waste and other pollutants that it was unfit for public use. By setting ambitious goals for the cleanup of contaminated waters, the Clean Water Act led to dramatic improvements in water quality and serious reductions in industrial pollution. Adoption of the Clean Water Act followed several high-profile disasters like Ohio's Cuyahoga River catching on fire because of the contaminants in the water. The Clean Water Act strengthened the statutory framework and required mandatory pollution controls and meaningful enforcement mechanisms.

The Clean Water Act set a new national goal "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters." It sought to ensure all waters be "fishable and swimmable" and provided the USEPA and states with the authority to set and implement the standards necessary to achieve these goals. Generally, states set water quality targets and standards that define specific cleanup measures or limit the amount of pollution that can be discharged into bodies of water; USEPA then reviews and approves these targets and standards. The Clean Water Act also established many different programs aimed at protecting wetlands, coastal waters, estuaries, and large ecosystems.

The year 2014 marked the fortieth anniversary of the SDWA. Utility managers know this as the law USEPA uses to establish and enforce national primary drinking water standards. These standards are known as the National Primary Drinking Water Regulations and set enforceable maximum contaminant levels (MCLs) for particular contaminants in drinking water or require ways to treat water to remove contaminants. Each standard also

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includes requirements for water systems to test for contaminants in the water to make sure standards are achieved. USEPA has established MCLs or specific treatment techniques for more than 80 contaminants and has also developed (unenforceable) secondary drinking water standards to address the protection of the public welfare (e.g., taste-and-odor issues).

The SDWA was amended in 1986 and again in 1996, expanding both the list of contaminants to be monitored and the scope of activities required to protect public drinking water and its sources (including lakes, rivers, reservoirs, springs, and groundwater wells). The original SDWA focused primarily on treatment as the means of providing safe drinking water at the tap. The amendments enacted in 1996 greatly enhance the concept of protecting drinking water from source to tap. To accomplish this, the amendments call for additional attention to be paid to protecting source water, training certified operators, establishing funds for water system improvements, and using public information to ensure safe drinking water. For an excellent overview, see the USEPA fact sheet titled "Understanding the Safe Drinking Water Act" (USEPA 2004).

The SDWA applies to every public water system in the United States and its territories (e.g., Puerto Rico, the US Virgin Islands, and Guam) and provides the statutory and regulatory framework to ensure that the requirements are both completed and enforced. In most cases, oversight and enforcement of water systems are the responsibility of the respective state drinking water programs. To formally assume this responsibility, states can apply to the USEPA for *primacy*, which gives them the authority to implement the SDWA requirements within their jurisdictions. To do this, states must be able to show that they will adopt standards at least as stringent as USEPA's and make sure water systems meet these standards. The Navajo Nation is the only tribal entity with SDWA primacy.

As of 2017, only Wyoming and the District of Columbia have not received primacy. States, or the USEPA acting as a primacy agent, make sure water systems test for contaminants, review plans for water system improvements, conduct on-site inspections and sanitary surveys, provide training and technical assistance, and take action against water systems not meeting standards.

The State Perspective Matters

Given the role of the state primacy agencies, it is essential for utility leaders to know all state-based requirements *and* to be familiar with the agency that is responsible for making sure a utility is in compliance. In most cases, the relationship between the water–wastewater utility and the state agency is well established. You should ensure managers and key operations staff get to know the state agency and the staff assigned to a given utility. Make sure you are aware of all required reports and communications and establish a regular dialogue with the key members of your state agency.

Other Key Federal Statutes

Another key federal statute usually enforced by states is the CWA of 1972. The purpose of this law is to address the pollution of water in the United States. Among other things, the CWA contains provisions regulating municipal wastewater treatment systems. Along the same lines as the SDWA, the USEPA has established and enforces requirements broadly prohibiting the discharge of pollutants into waters of the United States without a permit, referred to as an NPDES permit. For example, the discharge of treatment filter backwash residuals into an adjacent river either without an NPDES permit or in violation of a condition of a valid NPDES permit may likely result in an enforcement action by an appropriate authority. Notably, the CWA also addresses (1) the discharge or placement of dredged or fill material into waters of the United States (i.e., wetlands issues); and (2) the prevention of and responses to spills of oil and hazardous substances.

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RCRA (1976) is another key federal statute. In general, RCRA is characterized as the federal statute providing "cradle-to-grave" management and tracking of hazardous waste (e.g., spent solvents). The USEPA has established enforceable standards for the identification, management, transportation, and disposal of hazardous waste. Other portions of RCRA address (1) used oil management and (2) underground storage tank (UST) systems.

Importantly, the CWA prohibits anybody from discharging pollutants through a point source into a water of the United States unless they have an NPDES permit. The permit will contain limits on what can be discharged, what can be monitored, what are the reporting requirements, and other provisions to ensure that the discharge does not hurt water quality or people's health. In essence, the permit translates general requirements of the CWA into specific provisions tailored to the operations of each person discharging pollutants.

Another significant federal statute is the CAA (1970), which addresses air emissions from both stationary and mobile sources. The key component of the CAA is the National Ambient Air Quality Standards (NAAQS). Through the NAAQS program, USEPA regulates six ambient air pollutants determined to endanger public health and welfare (e.g., particulate matter). The CAA also addresses hazardous air pollutants and risk management planning. Drinking water utilities may possess certain operations requiring either CAA construction and/or operation permits (e.g., diesel generators) or risk management plans (e.g., chlorine cylinders).

Canada and Mexico

In Canada, the federal government has jurisdiction related to fisheries, navigation, federal lands, and international relations, including responsibilities related to the management of boundary waters shared with the United States and relations with the International Joint Commission. It also has significant responsibilities for agriculture, health, and the environment; plays a significant role supporting aquatic research and technology; and ensures national policies and standards are in place on environmental and health-related issues. Within the Canadian government, more than 20 departments and agencies have unique responsibilities for fresh water.

Water supply and sanitation in Mexico are characterized by achievements such as a significant increase in access to piped water supply in urban areas (88 percent to 93 percent) as well as in rural areas (50 percent to 74 percent) between 1990 and 2010. Additionally, a strong nationwide increase in access to improved sanitation (64 percent to 85 percent) was observed in the same period. Other achievements include the existence of a functioning national system to finance water and sanitation infrastructure with a National Water Commission as its apex institution, and the existence of a few well-performing utilities such as Aguas y Drenaje de Monterrey. In addition to ongoing investments to expand access, the government has embarked on a large investment program to improve wastewater treatment.

REFERENCES

USEPA. 2004. "Understanding the Safe Drinking Water Act." EPA 816-F-04-030, at http://water.epa.gov/lawsregs/rulesregs/sdwa/index.cfm.

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Chapter 2

Utility Management Overview

This chapter describes the nontechnical role of management and surveys management approaches. The purpose is to describe parameters of how a water–wastewater utility manager conducts the business of protecting public health and the consequent economic viability of the community. Included are the basics of developing a strategic plan, as well as an example of a simple strategic planning framework based on the effective utility management (EUM) "attributes of effectively managed utilities." Here also you will find suggestions on how to involve staff and stakeholders by tracking and reporting progress and success and by keeping your plan both current and continuously effective by revisiting and revising the plan on a regular basis.

From a technical and operational perspective, water–wastewater utility sector managers are stewards of water throughout its entire cycle—from the source (well, river, lake, reservoir), out to the community and back, and then back to the world again (river, lake, ocean, injection well, landfill, or farmer's field). In sector terminology, this encompasses supply, treatment, distribution, collection, treatment, disposal, and even reuse. This is the physical structure, or better, the infrastructure that encompasses how utilities deliver water, sewer, storm, and environmental services to their communities. In addition, adequate fire flow for residential, commercial, and industrial customers is also important.

More specifically, water utility managers are responsible for the daily operation of one of the most important assets in the community—the infrastructure and processes that harness, treat, and distribute water to the community. Inherent in this responsibility is the fundamental task of providing an adequate supply of potable drinking water and, in doing so, protecting the public health of those who consume that water.

WHAT EVERYONE FACES TODAY

The most prevalent management issues or, in some cases, trends facing water and wastewater utilities are addressed in cycles of strategic planning. Strategic planning initiatives, such as workforce management, influence the development of a utility's use of information,

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the technology required to manage its data, and how it plans for the care of its assets. In turn, strategic planning requires utilities to define future resources. The ability to communicate the value of a utility's investment in water infrastructure and services is another critical step in strategic planning, shown in Figure 2-1.

PLANNING AND STRATEGY

Organizations and businesses are successful for a variety of reasons: very talented people; great business concept; clever advertising campaigns; a savvy and aggressive sales force; or perhaps fundamentally sound and optimized manufacturing and distribution practices. Whatever the secret to success might be, one thing that most successful organizations and businesses have in common is the development and implementation of a sound business strategy. At the core of every good strategy is sound planning.

Water utility managers are familiar with plans—from routine work plans for the daily work of crews to long-term facility master plans that identify the needs of the organization for decades. Plans are common in many aspects of utility operations, both on the technical side and the management side of the organization. Much like other businesses, many utilities have developed a strategic plan to guide the organization.

DEALING WITH THE REALITIES OF THE CHANGING WORKFORCE

Making sure you have the right people with the right skill sets is important for any organization. In particular, for organizations like utilities that may have a wide variety of highly technical processes and practices, the right skills are imperative for efficient and effective operations. As a utility manager, one of your key roles and most pressing challenges is finding, training, and keeping the right people for the right jobs that contribute to a successfully run utility.

Chapter 4 covers a spectrum of workforce issues—both in the general North American population and specific to the water utility sector. These issues range from how to address the changing demographics of the workplace to how to find, train, and develop the next generation of utility employees. The issues include not only how to capture the vast amount of institutional knowledge and retain it, but also how to use it to train and build a talented, adaptable, and continually learning workforce.

The chapter also focuses on operator issues and some of the tricky realities of replacing a departing generation with highly established skills and a highly evolved sense of role and purpose with a group of people with different backgrounds, different expectations, and different views about the workplace.

MANAGING INFORMATION AND ASSETS

Information management and data management are urgent skills either for you to develop within your organization or for you to have immediate access to through contractual arrangements. From smartphones and iPads in our personal lives to any number of databases, software applications, and data-driven processes in the treatment plant, business office, or customer service center, we use, process, and manage data and information. Data and information are an essential part of your role as a utility manager. You rely on accurate data and information to make decisions, direct work, and make reports both up and down in the organization.

Chapter 5 covers the demanding challenge of managing data and information management in a water utility setting. The first portion of the chapter outlines some of the

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Figure 2-1 Strategic management of information

basics of how data flows throughout a utility organization. The second part details managing data across the many business processes found in a modern utility. The last part highlights some of the major trends in information management, including "Big Data," cloud technology and security, mapping interfaces, social media, and business intelligence. The chapter concludes with a focused consideration of utility security issues anchored by a proactive approach.

Continuing the theme of managing important information, chapter 6 covers some of the key aspects of asset management. This chapter begins with the basics, such as taking an inventory of assets, establishing the levels of service you will provide for your assets, and then conducting the risk/condition assessment to help set your priorities. After the basics are covered, the chapter then details how these practices and approaches link with capital planning, information management, and routine operations and maintenance.

VALUE OF WATER IN LIGHT OF VARYING ABUNDANCE AND SCARCITY

Perhaps one of the most pressing issues for water utility managers is trying to explain the value of water to customers, ratepayers, politicians, and the public in general. In some regions of the United States, like California, Texas, Nevada, and other parts of the arid Southwest, utilities and the communities they serve face significant and ongoing drought conditions. In other parts of the United States and Canada, communities have experienced record-breaking storm events—both in terms of quantity of precipitation and ferocity of

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the storms. And then there is the mounting cost of replacing aging infrastructure—especially for those communities that have old distribution systems carrying the water out and are also addressing consent decrees to fix inadequately designed sanitary and combined sewer systems. One community does not have enough water and the next has too much; another community is mandated to increase rates to fix a problem, and another is facing reduced revenues from either necessary conservative consumption or lack of use because of record rainfall.

Chapter 7 discusses this tricky interaction between the operational realities and demands on a utility, the finances needed to support these operations, and the support that is necessary to garner from ratepayers and governance to successfully establish a viable and sustainable financial situation for the utility.

Chapter 8 picks up where chapter 7 leaves off and carries the conversation about communications further, explaining the importance of effective communications and outreach as important tools in utility management. This includes a discussion about developing and implementing communication plans and strategies, as well as ensuring that you have the right people to develop and provide the right message.

STATUTORY, REGULATORY, AND POLICY ISSUES

All utilities are responsible for complying with the applicable federal, state, and local statutes and regulations that govern their operations. These statutes and regulations cover a full spectrum from how water is obtained and to what degree the water is purified to make it safe for the public to how compliance is proven and reported. Add to these issues the need to provide adequate fire flow for public safety, the need to comply with accounting and business rules, and a long list of rules and requirements that apply to all organizations regardless of the service they provide.

As a result, all utility managers need to understand both the breadth and depth of the statutory and regulatory requirements that fit with their role and also to a large degree those that apply to the entire organization.

Accordingly, chapter 9 provides an overview of environmental health and safety regulations—again with the focus on describing the broad requirements on the statutory and regulatory front, along with some discussion of the importance of communication with regulatory agencies, governing bodies, and the public about how the utility is meeting all of the many requirements.

EVERYDAY MANAGEMENT EXCELLENCE

Managing the organization requires attention to these nuts-and-bolts topics essential to every utility:

- **Customer service**
  - Expectations of internal and external stakeholders
  - Managing the customer service workforce
  - Defining customer service responsibilities
  - Business process management side of customer accounts
- **Operations and maintenance (O&M)**
  - Protection of source water
  - Water treatment plant operations and maintenance
  - Distribution system operations and maintenance

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- **Health and safety**
  - Integrating safety into operations and maintenance
  - Injury prevention strategies
  - Regulatory compliance
  - Establishing a safety program for staff and contractors
- **Emergency management**
  - Risk and resilience management
  - Water/wastewater agency response network (WARN)
  - Security practices
  - Emergency preparedness practices
  - Utility resilience index (URI)
- **Financial management**
  - Fiduciary guidelines, regulations, and constraints
  - Everyday business operations of the utility
  - Planning and financial management
  - Running the utility "like a business" and as a transparent public agency
  - Tracking and reporting performance, both internally and externally

As utility managers, you are "called to be responsible stewards of the natural, physical, financial, and human resources entrusted to your care." Much of that responsibility relies on the technical and operational skills your position demands. Many AWWA manuals, guidance documents, publications, periodicals, and training programs address these same management topics. Lists of these references have found a place in M5 because they are so fundamental to the everyday operation of a water–wastewater utility that you need to plan to employ them directly or indirectly every day on the job. The following general reference section lists some important management resources, including general management texts that are useful.

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