M36

Water Audits and Loss Control Programs

Fourth Edition

American Water Works Association

Contents

Chapter 1

Introduction: Auditing Water Supply Operations and Controlling Losses

Community water supply systems around the world have been instrumental in improving the human condition by providing essential water to promote public health and safety and to serve as a basis for economic development. For hundreds of years, societies have constructed infrastructure to withdraw water from available sources, to treat it to an acceptable standard, and to distribute it to communities, typically through buried piping distribution systems. Yet, for all their success in quenching human needs, many water utilities operate with considerable inefficiencies in terms of water and revenue losses. As the world grapples with the dilemma of a growing population but a finite amount of water, these inefficiencies need to be brought under a reasonable level of control. This manual offers water utilities a set of tools and approaches to instill accountability and control losses, including

- step-by-step procedures to conduct a water audit to assess the efficiency of the water distribution system and water accounting practices;
- definitions and implications of apparent (nonphysical) losses and real (physical) losses;
- specific techniques to identify, measure, and verify all water sources, consumption, and losses;
- example data inputs and sample calculations for each step of the water audit;
- references to freely available software tools to compile the water audit and plan leakage management activities;
- a road map to control apparent losses in metering and billing operations and to recover missed revenues;

- steps to implement a leakage and pressure management program to control real losses and preserve source water resources;
- planning steps to assemble the proper resources, information, and equipment to launch and sustain the accountability and loss control program;
- approaches for short-term and long-term goal setting for the loss control program;
- considerations for small water systems; and
- discussions and listings of actual water audit data and descriptions of successful water loss control being applied by North American water utilities.

Many water utilities suffer a variety of losses. Most operators recognize distribution system leakage, categorized under the heading *Real Losses*, as a primary type of loss. However, water suppliers also suffer losses from poor accounting, customer metering inaccuracies, and unauthorized consumption. These losses are collectively labeled *Apparent Losses* and have a negative impact on utility revenue and consumption data accuracy. While it is essential that system operators employ means to control such losses, the initial step is to assemble a water audit to identify the nature and volumes of losses existing in a water utility, and the water resources and financial impacts that these losses exert.

THE WATER AUDIT AND WATER BALANCE

Good management of any resource requires that the supplier maintain accurate records of transactions and deliveries of the commodity provided to its customers. The *audit* is a common function in the world of finance and accounting, and it typically denotes activities that systematically review an organization's financial records and accounts to confirm their accuracy. Similarly, the *water audit* involves a review of records and data that traces the flow of water from its source and treatment, through the water distribution system, and into customer properties. The water audit usually exists in the form of a worksheet or spreadsheet that details the variety of supply, consumption, and loss components that exist in a community water system. The *water balance* summarizes these components and provides accountability, as all of the water placed into a distribution system should, in theory, equal all of the water taken out of the distribution system.

In 2000, the International Water Association (IWA) published the manual *Performance Indicators for Water Supply Services* (Alegre et al. 2000). This publication includes a description of a water audit method developed during the period of 1997–2000 by the IWA Water Loss Task Force (now called the Water Loss Specialist Group), which at the time was a five-country group that included participation by the American Water Works Association (AWWA).* Until then, a multitude of different water auditing practices had existed around the world, and the primary focus of the task force was to draw on the best practices of the various approaches and craft them into a single, standard best management practice methodology. The method needed to be applicable worldwide, across the spectrum of differing system characteristics and units of measure. Many of the features of the resulting best practice methodology were drawn from the original AWWA Manual M36, *Water Audits and Leak Detection*, published in 1990 and revised in 1999. Shortly after the task force published its new methodology, the AWWA Water Loss Control Committee (WLCC) voiced support for the method in its committee report "Applying Worldwide Best Management Practices in Water Loss Control" published in the August 2003 edition of *Journal AWWA* (Kunkel et al. 2003). In support of this approach, the WLCC comprehensively revised and expanded Manual M36 in creating the third edition (2009). This edition carefully detailed

* The IWA Water Loss Task Force has grown considerably and was elevated to become the IWA Water Loss Specialist Group in 2011.

the best practice water audit method and provided significant guidance on innovative loss control technologies and approaches for planning the loss control program.

This fourth edition of Manual M36 continues to promote the standard, best practice water audit method created by IWA and AWWA, and the method is explained in detail in chapter 3. The WLCC recommends this method as the current best management practice structure for water utilities to compile a water audit of their operations. In addition to reliably tracking water consumption and losses using this method, water utilities also have a variety of effective means to economically control apparent and real losses. Great innovation in loss control approaches and technologies has occurred since the early 1990s. Many of these techniques are explained in chapters 5 and 7. The final chapters of this manual provide guidance on planning and sustaining the loss control program and considerations for small systems.

This fourth edition improves on the third edition manual in several ways. First, the AWWA Free Water Audit Software (2014), which was briefly mentioned in the third edition, is now fully integrated into the guidance and examples of this edition and is the tool of choice recommended by the WLCC for water utilities to conduct the annual water audit. The WLCC created and issued the Audit Software in 2006 and has since issued several upgraded versions. Version 5.0 was issued in 2014.

Second, an entirely new section (appendix A) has been included to detail the methods to ensure valid, accurate water production data and to identify best practices to accurately quantify the *Volume of Water Supplied* to the water distribution system. Production water volumes, which are the supply volumes at the water source or supply leaving water treatment plants, represent the largest and most important quantities in the water audit, and the fourth edition provides highly detailed guidance in ensuring reliability in these quantities. A third major addition to the manual is a comprehensive description on the use of a free software tool known as the Leakage Component Analysis Model (LCA Model). This model became available to the water industry in 2014 as part of a research project administered by the Water Research Foundation and sponsored by the US Environmental Protection Agency (WRF 2014). The LCA Model offers a clear and concise method to analyze data on leak and water main break events occurring in a water utility, and uses the data to define the parameters of an economic leakage and pressure management program tailored for the needs of the individual water utility. The LCA Model offers a user-friendly instrument to automatically execute the calculations that were merely listed in the third edition.

Finally, the fourth edition includes numerous examples and data of validated water audits from hundreds of North American water utilities. The use of the AWWA water audit has increased dramatically since the release of the third edition of Manual M36 in 2009; and the fourth edition provides a representative glimpse into the validated data that is fast being compiled by the North American water industry. The fourth edition offers updated and improved content that supersedes the third edition, and readers will find this new edition to be invaluable in their efforts to establish sound accountability and efficiency in their water supply operations.

THE IMPORTANCE OF WATER AUDITS AND LOSS CONTROL

Strong water loss control produces benefits in four primary ways:

1. Through water resources management, by limiting unnecessary or wasteful source water withdrawals
2. Financially, by optimizing revenue recovery and promoting equity among ratepayers

3. Operationally, by minimizing distribution system disruptions, optimizing supply efficiency, and generating reliable performance data
4. Through system integrity, by reducing the potential for contamination in the water distribution system

Water suppliers have obligations in all of these areas: they must act as stewards of the valuable water resources they manage; they must be fiscally responsible to their customers, shareholders, and bondholders; and they must maintain safe, reliable operations that provide quality water service to their communities. Properly executed water auditing and loss control programs help water utilities meet their obligations in all of these areas, to the benefit of their customers and their own bottom line. The specific benefits of water auditing and loss control include the following:

- *Reduced apparent losses*. Reducing apparent losses creates a financial improvement by recovering lost revenues from customers who have been undercharged or have gained water in an unauthorized manner.
- *Reduced real losses*. Reducing real losses saves water purchase and operating costs including power, maintenance, and treatment costs. Because leakage volumes are a considerable portion of system input for many water utilities, expansion of water supply infrastructure might be deferred if successful leakage control is achieved. Likewise, better use of existing resources may ease drought restrictions or allow economic development to occur without exploiting new water resources. Reducing leakage volumes results in a corresponding reduction in the operation of equipment, thereby extending the interval between scheduled maintenance.
- *Improved data integrity*. Sound water auditing improves the accuracy and integrity of water system input volumes and customer consumption. Knowing true water consumption patterns promotes better water resources management, confirms water conservation benefits, and aids long-term planning.
- *Better use of available water resources*. Controlling losses helps stretch existing supplies to meet increasing needs, thus avoiding the exploitation of new water sources. Environmental impacts are limited given that no more water is withdrawn from sources than is absolutely needed.
- *Increased knowledge of the distribution system*. During the water auditing process, distribution personnel become familiar with the distribution system, including the location of mains and valves, pressure levels, and demand variations. This familiarity helps the utility to respond quickly to emergencies, such as water main breaks, and provides a basis for optimization of supply operations.
- *Increased knowledge of the customer metering and billing systems*. The water auditing process provides the auditor the opportunity to review the workings of the customer billing system. For many water utilities, inadvertent procedural or programming gaps exist in billing operations, allowing certain customers to receive water without paying for it.
- *Safeguarding of public health and property*. Improved maintenance of the water distribution system helps reduce the likelihood of property damage and safeguards public health.
- *Improved public relations*. Consumers appreciate maintenance of the water distribution system. Field teams performing loss control activities provide visual assurance that the distribution system is being maintained. Consumers also appreciate value for their money. They expect high-quality service at a reasonable price.

Efficient delivery of high-quality water, along with affordable, equitable water rates, creates a strong reputation for the water utility in the minds of its customers.

- *Reduced liability*. By protecting public property and health and providing detailed information about the distribution system, water audits and loss control programs help protect the utility from expensive lawsuits.
- *Reduced disruption to customers*. More leaks are repaired on a proactive basis rather than developing into large leaks or main breaks that disrupt service and cause damage and customer ill will.
- *Improved asset management*. By effectively managing leakage and optimizing pressure in the water distribution system, water main and service connection leakage can be reduced and pipeline asset life can be extended.
- *Favorable reviews from the financial community*. Effective operations and accountability instill credibility for the water utility in the eyes of the financial community, helping the utility to secure funding to sustain sound upkeep of the operation well into the future.

In summary, water and revenue losses are wasteful to the water utility, its customers, the environment, and society at large, while good accountability and loss control offer many benefits. It is likely that many, if not most, North American water utilities can strongly benefit from improvements in their level of accountability and loss control practices. In this way, this manual serves as a valuable guide for water utilities.

GETTING STARTED

Just as a proactive water utility carefully tracks its finances, effective utilities should also track the water supply that they manage. Historically, the motivation for a water utility to compile the annual water audit was strictly voluntary. However, since 2000, several American states have enacted requirements for annual water audits, and the number of water utilities routinely compiling water audits is growing. For most water utilities, getting started is the largest hurdle. Perhaps in prior generations, utility personnel did not know where to turn for guidance on how to get started in the water audit process. However, today's water utilities have available to them the detailed guidance provided in this manual: the AWWA Free Water Audit Software (2014), the LCA Model, and information on AWWA's Web site (www.awwa.org). Hence, utility personnel can readily obtain and employ the tools and guidance to quickly identify and quantify their losses and the impacts. In as little as several hours, readily available data can be accessed and input into the standard water audit format, revealing preliminary loss control standing and cost impacts. *The most important step is to just get started, and the guidance and tools provided in this manual give utilities everything they need to do this!*

THE FUTURE OF WATER SUPPLY EFFICIENCY

In 2001, AWWA commissioned an extensive survey of state and regional water resource and environmental agencies in the United States to uncover the extent and usefulness of their water accountability statutes and regulations. The project, titled *Survey of State Agency Water Loss Reporting Practices* or the "States Survey Project," was successful in garnering valuable information from 46 jurisdictions, including 43 state agencies and 3 regional agencies (Beecher 2002). The results of the survey found that widely varying language existed throughout many regulations and statutes of these agencies. Many organizations defined water losses as some form of *unaccounted-for* water but left the components

Table 1-1 Guidance for the use of proper terminology in the standardized water audit methodology

Non-Preferred Term	Preferred Term	Reason
Unaccounted-for water (UFW)	Non-revenue water (NRW)	All water entering a distribution system can be defined as a component of either authorized consumption or water loss.
Percentage of system input volume to measure water loss performance	Suite of key indicators for water loss as outlined in AWWA audit method in chapter 3 (e.g., gal/service connection/d)	A percentage-based expression obscures the underlying causes of water loss and impedes realistic solutions based on system specifics.

included in this parameter subject to interpretation *and manipulation*. As an example of the latter, some utilities included volumes from known leaks in "accounted-for" water categories, thus underestimating actual leakage volumes, which are a loss. In attempting to gather voluntary data from large water utilities, one state agency found that water utilities that earnestly attempted to audit their supplies reported figures that appeared less flattering than counterparts who reported unrealistically low losses, with no substantiation of their data (McNamee 2002). This type of gamesmanship reflects poorly on the US water industry, which has proven itself up to any challenge, including that of reliable water auditing and loss control. The final report of the States Survey Project was astute in its recommendation that "a better system of accounting is necessary if accountability is to be instilled in water utilities" (Beecher 2002).

The WLCC supports the methods offered in this manual as the "better system of accounting" called for in the States Survey Project report. Since 2003, AWWA has recommended against the use of the imprecise term *unaccounted-for water* because it does not exist in the best practice water audit method, and its use creates more confusion than guidance to water utilities. Instead, the precisely defined term *non-revenue water* should be employed, as given in this guidance. The use of non-preferred and preferred terminology is given in Table 1-1.

The WLCC holds that the methods in this manual are workable, meaningful, and offer the greatest potential to bring about improved accountability and water efficiency in water utilities. The methods can enhance service for water customers, improve the bottom line for water utilities, and better manage water resources for the common good. It is recommended that these methods become the model approach for quantitative management of water resources in North America for water utilities, professional organizations, regulatory agencies, and all stakeholders who support safe and reliable water.

Across North America, several state, provincial, and regional agencies have enacted water auditing requirements applying the methodology first advocated by the AWWA WLCC in 2003. Although the movement toward routine, standardized water auditing is still in the early stages, validated data for hundreds of water utilities have been compiled, allowing water managers, regulators, and policy analysts to gain the first truly representative assessment of the quantitative management of water supplies in North America. This will allow for strategic targeting of loss control efforts by individual water utilities and coherent policy and statutory decisions by water resource managers and regulators. The number of states and provinces enacting new water auditing requirements will undoubtedly grow in coming years, and water utilities must be prepared to assess their water supply management in a more comprehensive manner.

Water accountability and loss control is garnering increasing prominence in water resources management, particularly as limitations in available water resources are

occurring in many parts of the world. New water sources will continue to become more difficult and costly to develop, water quality regulations and customer expectations will increase the value of water, and growing populations and economies will need adequate water supplies on a continuous basis. All of these drivers will combine to create an increased focus on water accountability, efficiency, and conservation. By employing the methods included in this manual, water utilities will have the tools to meet these growing challenges.

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