

# Water Audit and Water Loss Abatement Program

## Background

Every gallon of water lost or wasted due to system inefficiencies comes at an increasing cost to our communities and natural resources. Water audits and water loss abatement programs, more commonly known as water loss control programs, are valuable water management tools that can improve the efficiency of water production and delivery within all utilities in the state. It is important that water systems focus on the efficiency of their water supply operations while promoting water efficiency and conservation to their customers.

While not currently required by law, an essential tool to determine the efficiency of a water system is the water audit. Water audits are routinely used by utilities and have proven to be extremely beneficial in identifying areas for system improvement. These improvements have saved utilities money and provided customers with a more reliable water supply.

Different types of water audits are used to account for water activity in a system. Two options are the small system water audit, which was developed from the N.C. Division of Water Resources' local water supply plan (LWSP), and the American Water Works Association (AWWA) water loss control committee's free water audit.

The need for a standardized water audit was identified by AWWA, and through the efforts of its members, the free water audit has been made available by going to <http://www.awwa.org/Resources/WaterLossControl.cfm?ItemNumber=48511>.

While the AWWA water audit applies to all systems, smaller systems (less than 10,000 people) with more limited resources may wish to complete a slightly less comprehensive audit. DWR has developed an alternative water audit to meet this need. A link to the free software will be on the division's website soon.

Information and technical assistance regarding the use of either of these audits can be found by going DWR's website at <http://www.ncwater.org>.

## Applicability

A water audit is the first and most important best management practice a utility should implement, and lays the foundation for any water loss control program. This BMP is intended for all utilities and should be considered by a utility that:

- Needs to ensure its customers are fairly paying for the amount of water they are receiving.
- Needs to reduce water losses to ensure an adequate future water supply for its customers.
- Would like to analyze the benefits of reducing non-revenue water.

- Does not conduct periodic water audits.
- Wants to determine how under-registering meters and unmetered users are impacting revenue.
- Does not have an active water loss control program.

To maximize the benefits of this BMP, the utility should use information from the water audit to implement effective water loss control strategies, revise meter testing and repair practices, reduce unauthorized water use, and improve accounting for authorized, un-billed water users.

## **Description**

Water audits and water loss control programs are effective tools for the accounting and management of all water activity in a system. Performing a reliable water audit is the foundation of proper water resource management and loss control in water systems. Interest has increased in revising and developing water audit procedures to move away from simply considering “unaccounted for water” to a systematic methodology of accounting for all water activity. The structured approach of a water audit allows a utility to reliably track water uses and provide the information to address unnecessary water and revenue losses. The information that comes from a water audit is valuable in setting performance indicators and goals and to cost-effectively reduce water and revenue losses.

### The Water Audit

A water audit accounts for water processed by a utility. The audit starts with an accurate accounting of raw, treated and distributed water. In an ideal water audit, the accuracy of the raw water meters and their output should be verified. This production is then compared to authorized consumption, both billed and un-billed, to determine water loss in the system. Water loss is divided into apparent water loss and real water loss.

- **Apparent:** Water loss due to meter accuracy error, data transfer errors between meter and archives, data analysis errors between archived data and data used for billing/water balance, and unauthorized consumption including theft. The cost of apparent water loss is estimated using a utility’s retail water rates.
- **Real:** Water loss due to leakage and excess system pressure. Real water loss can be reduced by more efficient leakage management, improved response time to repair leaks, improved pressure management and level control, improved system maintenance, and replacement and rehabilitation. The cost of real water loss is estimated using marginal production costs, such as energy and chemicals needed to treat and deliver the water.

The water audit can also analyze billed versus metered consumption, large meter sizing, pump efficiency and economic leakage. The water audit may be expanded or

contracted depending on the size of the system. A utility that wants to improve water efficiency will conduct the water audit every year.

### Completing the Water Audit

The water audit is basically accomplished in two steps:

1. Collect data to perform the water audit.
2. Verify data collected.

The collection of data for the water audit is called the top-down approach. The verification of the data used in the water audit is called the bottom-up approach. Both approaches must be completed in order to obtain reliable results from the water audit.

For the top-down approach, a desktop water audit using existing records and estimations is used to provide an overall picture of water losses. Small utilities that have an updated LWSP would benefit from using the small system water audit because they have already gathered a substantial portion of the data needed to complete the top-down approach. If a utility has conducted a water audit using the AWWA M36 Manual, they have already completed a more in-depth process. The small system water audit spreadsheet included in this BMP is only recommended for small utilities with populations below 10,000 people and who do not consider the AAWA water audit appropriate for their system.

Utilities that use the small system water audit should first print the definitions to become familiar with the terms needed to complete the water management table. The water management table is the main spreadsheet used to complete the audit. The spreadsheet only accepts values in the non-shaded cells. Cells with red triangles at the top right corner contain instructions. Use your cursor to roll over the red triangle to see the instruction box. The spreadsheet has three major components: water delivered by the utility, water used by customers and water and revenue loss experienced by the utility. Losses are calculated by the spreadsheet using tools such as the Meter Error Table, the Cost to Produce Calculator, and the Retail Charge Calculator that are included as tabs at the bottom of the spreadsheet.

Some records that will be needed to complete the top-down approach include:

- Quantity of water entering the system.
- Customer billing summaries.
- Leak repair summaries.
- Meter accuracy test.
- Meter change-out summary.
- Water production cost.
- Retail rates for water.
- Permitted fire hydrant use.
- Other records that may be kept on water theft and unmetered uses such as line

flushing or street cleaning.

Once the top-down approach is complete, the utility should have an overall picture of apparent and real losses along with its associated revenue loss.

For the bottom-up approach, the process of verifying the data used in the water audit is performed. This process involves a detailed investigation into actual policies and practices of the utility and includes activities such as:

- Checking water consumption values used in the billing system for different user types.
- Performing meter calibrations for a sample set of user types.
- Improving estimates of water consumed by un-billed (i.e. fire department, and public works department) and unauthorized users.
- Properly metering all authorized users.

This part of the audit is phased in during several years and will help shape the objectives and priorities to improve system efficiency.

Tools that can be useful to accomplish the bottom-up approach include models capable of analyzing system pressure, night and zonal flows, and the practice of keeping good leakage repair records that show lag times to repair a known leak. Once the bottom-up approach is complete, a utility should have enough reliable data to establish a baseline for water loss and revenue loss. From here, development or modification of the water loss control program can begin.

### Water Loss Abatement Program

In order to reduce water loss and revenue loss due to leakage, a utility should develop and maintain a proactive water loss control program. The program should identify objectives based on results from the water audit, and set goals to reduce water and fiscal losses. A structured approach to leakage management has proven to be successful in limiting losses. Potential elements of an active water loss control program include:

- Conducting regular inspections and soundings of all water main fittings and connections.
- Using a water loss modeling program. A model can range from the AWWA M36 manual water audit spreadsheet to a commercially available statistical model.
- Metering and managing individual pressure zones.
- Establishing district metering areas (DMA) and measuring daily, weekly or monthly flows with portable or permanently installed metering equipment.
- Continuous or intermittent night-flow measurement.
- Installing temporary or permanent leak noise detectors and loggers.
- Reducing repair time on leaks. Long-running small-to-medium size leaks can result in the greatest volume of annual leakage.

- Controlling pressure just above the utility's standard-of-service level taking into account fire requirements, outdoor seasonal demand and requisite tank filling.
- Operating pressure zones based on topography.
- Limiting surges in pressure.
- Reducing pressure seasonally and/or where feasible to reduce loss from background leaks.

If a utility has not had regular leak surveys performed, it will probably need at least three leak surveys performed in consecutive years, or every other year for the following purposes:

- The first survey will uncover leaks that have been running for a long time.
- The second survey will uncover additional long-running leaks whose sounds were masked by larger nearby leaks.
- By the third survey, the level of new leaks should start to approximate the level of new reported leaks.

The utility should make every effort to inform customers when leaks exist on their side of the meter. If customer service line leaks are significant, a utility may want to consider making the repairs itself or shutting off the water until the leak is repaired.

The water loss control plan should address areas such as:

- Customer meter inaccuracy due to meter wear, malfunction or inappropriate size or type of the meter.
- Data transfer error when transferring customer metered consumption data into the billing system.
- Data analysis errors including poor estimates of un-metered or un-read accounts.
- Inaccurate accounting resulting in some accounts not being billed for water use.
- All forms of unauthorized consumption including meter or meter reading-tampering, fire hydrant theft by contractors, unauthorized taps, and unauthorized restoration of water service cutoffs.
- Un-metered municipal connections. Every effort should be made to meter municipal connections in order to better account for water use. Spikes in water use should be reported to the user as this may indicate a leak.
- Field Response and maintenance procedures.

## **Implementation**

To successfully implement this BMP, the utility should start by forming a working group from the following work areas: management, distribution, operations, production, customer service, finance and conservation. Each of these work areas has an essential role to play in implementing this BMP. Smaller utilities may have the same person performing several of these functions; therefore the working group may just be one or two individuals. The utility should also consider a public involvement process to solicit outside input and enhance public relations.

Initially, the working group should focus on gathering relevant data that will form the basis for completing the top-down approach. Some questions that should be addressed during this process are:

- Should we test production meters and how often? Commercial meters more than one inch? More than 2 inches?
- Should we replace or repair  $\frac{5}{8}$ -inch and  $\frac{3}{4}$ -inch meters? How often?
- How inaccurate are the  $\frac{5}{8}$ -inch and  $\frac{3}{4}$  inch meters on average when they are replaced?
- How do we estimate total leakage from each leak based on the leakage flow-rate and duration of leakage from time reported to when it is fixed?  
How do we improve this process?
- How long does it take to repair leaks? How do we reduce this time? (The repair logs should be itemized by size of leak).
- How are customers encouraged to report leaks?
- Is our system for tracking the location of leaks and our method to calculate when it is cost-effective to replace mains and service lines adequate? How do we improve this process?
- Do meter readers inspect for and report leaks?
- How do we adjust consumption records when billing records are adjusted?
- How do we improve the optimal use of backwash and other in-plant water?
- How can we improve our theft reduction program?

Based on data collection efforts by the working group, the utility should have enough information to complete the top-down approach, as well as identify ways to improve the information for future audits.

In conducting the bottom-up approach, the working group should focus on evaluating data handling procedures and performing field investigations to improve the quality of data used. Activities can include:

- Checking the customer billing system for water consumption data handling errors.
- Categorizing user types by meter size and consumption volume to check for gross irregularities in consumption.
- Performing meter accuracy tests for a sample set of various user types.
- Performing investigations to identify unauthorized water use among a sample set of various user types.

The top-down and bottom-up approaches to completing the water audit should be incorporated into the working members' job duties in order to maintain a set of good objectives and priorities to be performed through the water loss control program.

## **Schedule**

To accomplish this BMP, the utility should:

- Gather the necessary data to complete the top-down approach, and perform the water audit within the first 12 months of implementing this BMP.
- Begin to make bottom-up refinements in the 12 months immediately following the completion of the top-down approach.
- Begin to develop or modify the water loss control program immediately after making refinements to the water audit. Development of the water loss control program can occur simultaneously while performing the bottom-up approach, but it is advised to obtain the best data reasonably possible before investing substantial capital to address efficiency objectives.

## **Scope**

To accomplish this BMP, the utility should:

- Conduct periodic water audits in accordance with the methodology in this BMP manual, or use the AWWA M36 Manual.
- Develop and perform a proactive distribution system water loss control program and repair identified leaks.
- If the audit warrants, implement:
  - A pressure reduction strategy.
  - A program to reduce real losses including a leak detection and repair program.
  - A program to reduce apparent losses.
- Advise customers when it appears that leaks exist on the customer's side of the meter and evaluate a program to repair these leaks.

## **Documentation**

To track the progress of this BMP, the utility should maintain and have available the following documentation:

- A copy of each annual system water audit and a list of actions taken in response to the water loss control program.
- An annual leak detection and repair survey, including number and sizes of leaks repaired.
- The number of customer service line leaks identified and actions taken to repair these leaks.
- Pressure reduction actions taken.
- Updates made to the billing system.
- Meter change-out efforts.
- Theft elimination efforts.
- Annual revenue increase through water loss reduction efforts.

## **Determination of Water Savings**

Water savings is an integral part of the water audit process and should be revealed in a water audit report. Water savings should become evident after completing the water audit and execution of strategies in the water loss control program. Whether a system chooses to use the DWR's small system water audit or the AWWA free water audit, both audits include metrics that provide for the visualization of actual savings resulting from program enhancements. Total apparent and real water losses can be used as a measure of improvement in volumetric losses, and the cost of apparent and real water losses can be used as a measure of reduction in revenue loss.

## **Cost-Effectiveness Considerations**

Direct costs that should be considered in implementing this BMP include the initial and ongoing costs to perform and update the water audit and the water loss control program, capital costs for items such as leak detection equipment, billing software upgrades and repairs to the system. Utilities may wish to do the work in-house with technical staff or use outside consultants and contractors.

A cost benefit analysis should be incorporated as part of a utility's overall strategy to reduce losses and improve efficiency. The cost benefit analysis should measure the cost of system software and hardware improvements against anticipated benefits in revenue gain. The analysis should also predict when the utility should start seeing a return on investment from actions taken in the water loss control program.

For comments or questions regarding the Water Audit and Water Loss Abatement Program BMP, please contact the water efficiency specialist of the Water Supply Planning Branch at 919-707-9021.

## **References**

- Water Loss Control Manual, Julian Thornton, McGraw-Hill 2002.
- M36 Manual, AWWA, 2009 Third Edition.
- Applying Worldwide BMPs in Water Loss Control, AWWA Water Loss Control Committee, Journal AWWA, August 2003.
- Survey of State Agency Water Loss Reporting Practices: Final Report to the AWWA Technical and Education Council, Beecher Policy Research, 2002.
- Benefit Cost Analyses of Leak Reduction Program: A Note for the Canadian Water and Wastewater Association, Alan Lambert, 2002.

## **Case Study for a Water Audit and Water Loss Abatement Program**

### **Mars Hill, North Carolina**

#### Background

Mars Hill is a small town in the southern portion of Madison County, North Carolina. The town's history is closely linked to Mars Hill College, the oldest educational institution still in its original location in Western North Carolina. It is part of the Asheville Metropolitan Statistical Area.

The town's population was 1,869 according to the 2010 U.S. Census. According to the 2011 local water supply plan update, the town had a year-round service population of 3,150 people. The total included 1,200 students with 702 residential connections and 124 gallons per connection per day. Mars Hill withdraws their water supply from Popular Cove Reservoir on Big Laurel Creek.

In 2008, the North Carolina General Assembly provided N.C. Department of Environment and Natural Resources with funding for the most drought vulnerable water systems in order to have consultants complete a detailed water audit. Using the AWWA Water Loss Control Committee Free Water Audit, the consultant reported that Mars Hill's had an estimated non-revenue water loss of 38 percent.

In 2012, the town staff believed this figure was reduced to between 20 percent and 25 percent. The consultant provided several valuable recommendations and the town of Mars Hill wants to find and reduce non-revenue water loss and improve their water system in other ways as well.

#### Water Audit Results

The main recommendation from the water audit was to continue to audit the water system in future years. Most of the original input data was taken from estimates, so metering all water use is a key to more accurate data. Other recommendations included:

- Troubleshoot billing software.
- Replace Mars Hill College (MHC) turbine meters with compound meters.
- Active leak detection for the cross-country transmission line.
- Replace MHC's two 6-in. meters and the 2-in. Madison Manor meter with compound auto-read meters.
- Active leak detection workshops for Mars Hill's staff.
- Develop Unidirectional Flushing Strategy and Valve Inventory/Exercise Program.
- Maintain Standardized Leak Detection/Repair and Flushing Records.
- Add distribution system personnel to support development of leak detection program.

- Develop meter inventory and systematic replacement of meters seven years or older with automatic read meters; target (minimum) between 5 percent and 10 percent replacement each year.
- Perform water rate study.

Actions that have been incorporated into the utility's standard operation procedures to date:

- The town has added distribution personnel, per the audit's recommendation.
- Successful efforts have been made to reconcile outliers and glitches in the software of the billing system.
- Missing accounts were restored and all are metered. Un-billed accounts are now in consumption records.
- The town is setting aside funds (approx. \$16,000) to replace the Mars Hill College turbine meters with compound meters (Four 2-inch meters and one 6-inch meter).
- Two 6-inch meters are being priced for replacement.
- The 2-inch Madison Manor meter was replaced.
- The town and a consultant performed leak detection on their cross-country transmission line. Based on finding numerous problems, they are replacing this old, high-pressure line with 8-inch ductile iron in 2012.
- Active leak detection was performed on the Bailey Street line.
- Town staff was trained in active leak detection techniques.
- One of three recommended large pressure-release valves for pressure management will be installed with the new cross-country water line.
- Town staff are now keeping records on leak detection, repairs and flushing.
- Town staff regularly evaluate unauthorized consumption.
- A radio-read meter replacement program has begun; 107 out of 800 meters have been replaced thus far with the oldest meters being replaced first.
- The town did a water rate study and now has an increasing block rate. The town formerly had a fixed flat-rate for water rate structure.

Mars Hill has demonstrated that by undertaking a Water Audit and Water Loss Abatement BMP, they are progressing towards a more efficient water system. As Mars Hill continues to incorporate the recommendations of the water audit, they will continue to reduce their water losses and increase their revenues.

The town manager indicated he would be glad to discuss the Water Audit and Water Loss Abatement Program with anyone regarding the successes they have had in Mars Hill. Mr. Daryl Boone can be contacted at 828-689-2301.