Instructions for Completing an American Water Works Association (AWWA) Manual 36[1] Water Audit Using AWWA's Free Water Audit Software v5.0

Prepared for the Massachusetts Department of Environmental Protection
By
Weston & Sampson Engineers, Inc.

This guide steps through the AWWA M36 water audit process focusing on entry of data. AWWA's Manual 36 (M36) provides a thorough discussion of the purpose and value of a water audit. The M36 is a recommended reference guide for completing an audit in addition to this instruction document.

[1] American Water Works Association (AWWA) Manual 36 – Water Audits and Loss Control Programs, 4th Edition
AWWA Free Water Audit Software v5.0 at https://www.awwa.org/resources-tools/water-knowledge/water-loss-control.aspx

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1.0 INTRODUCTION

Why perform a water audit?

- Evaluate quality and efficiency of operations
- Understand the nature of water losses and manage their magnitude
- Maintain confidence with customers and decision makers
- Identify and reduce water losses

What tools do you need?

- Water audit software is free and can be obtained online (see footnote on page 1)
- Microsoft Excel 2010 or later to run the software
- AWWA Manual M36, 4th Edition is strongly recommended as a reference material and is available through the AWWA online store

What data will you need?

Accurate data for the water audit period selected including:

- Volumetric data on water supply, customer meters, estimates for losses, and other water uses
- Basic information about the distribution system
- Financial information including water rates and operating costs

Things to keep in mind:

- Be skeptical: is the data representative, complete, accurate and reliable?
- Be pragmatic: given available resources, focus on accuracy of the largest volumes (source meters) and what actions can make the biggest difference.
- Set aside enough time to acquire the data and perform the evaluations, compiling, validating, and analyzing information will be a significant effort, but is essential to meaningful results.
- Document how you collect the data, this will streamline future audits and help identify areas of improvement.

Who should be involved?

- Key personnel involved with water treatment, distribution, and meter installation, reading, and billing
- Consider a kick-off meeting to discuss the purpose of the audit and ask questions on how data is collected
- After entering the data in the M36 software, scrutinize the validity of the data and follow-up with key personnel to fine-tune the audit.

Appendix A includes a guide for collection of data for the audit. Data should be collected before starting the water audit. Knowing the source and having confidence in the data is integral in completing the M36 water audit.

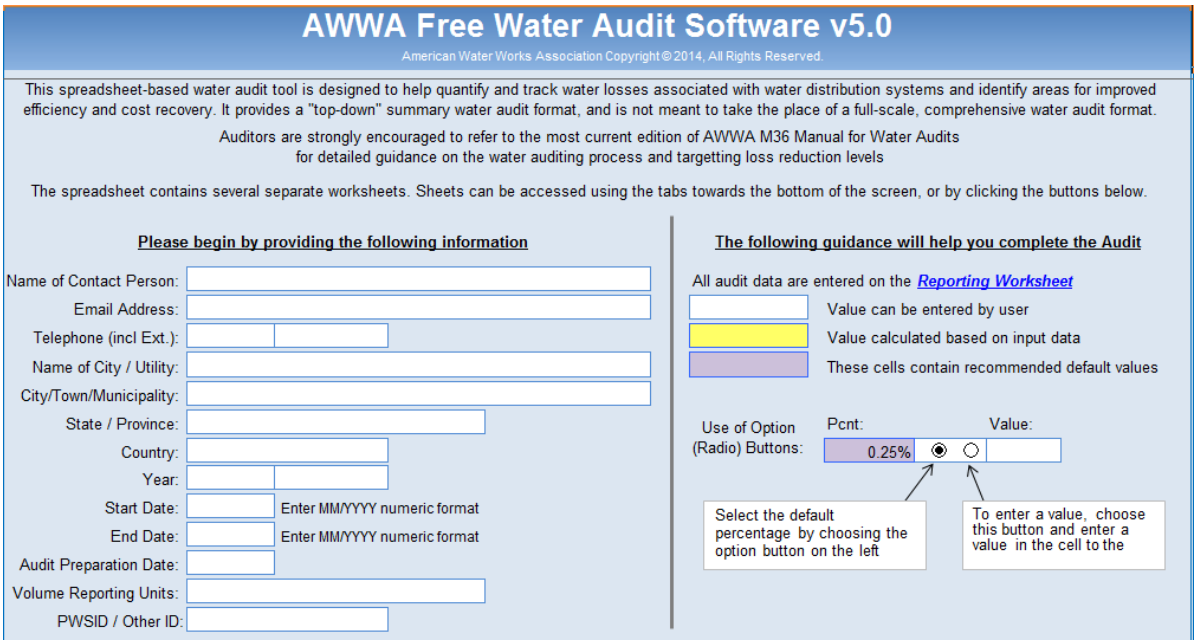
Appendix B provides definitions of terms taken directly from the M36 water audit software.

Appendix C includes helpful references and tools for use when completing the water audit and for improving data collection for subsequent audits.

2.0 GETTING STARTED

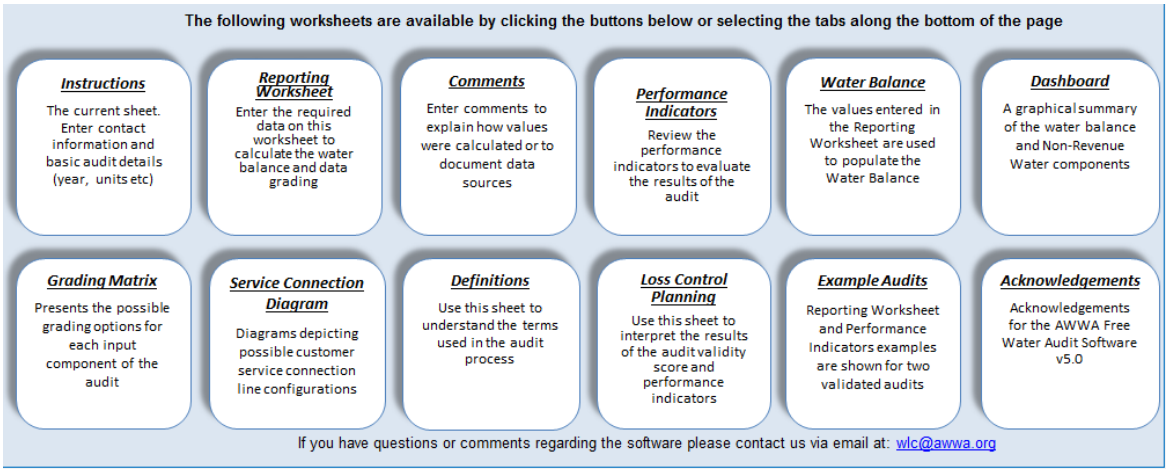
Open the software to the **Instructions** tab.

The **upper half** of the tab asks for basic information on the Public Water Supply (PWS) and explains how to enter data. On the **left side** of the page, enter general information regarding the PWS. An audit typically is performed over an entire calendar year, but can be performed over a fiscal year or shorter duration if desired.



As shown on the right side of the **Instructions** tab, data should be entered directly into the white spaces in the **Reporting Worksheet**. Several categories/values on the **Reporting Worksheet** are automatically calculated based on other entries; these cells are shaded yellow. Purple cells indicate a recommended default value, used for various usage calculations. Red cells indicate that a value for a usage calculation must be provided by the PWS (in percentage form). In some cases you will have a choice between the default estimate calculated by AWWA of 0.25% of **Water Supplied** or values specific to the PWS that can be confidently derived.

The **lower half** of the **Instructions** tab shows all the tabs in the Water Audit Workbook. Each block is a link to that specific tab in the worksheet. This manual focuses on the steps for filling out the **Reporting Worksheet**. To learn more about the other tabs, click the boxes in the Water Audit Workbook (example shown on the next page).



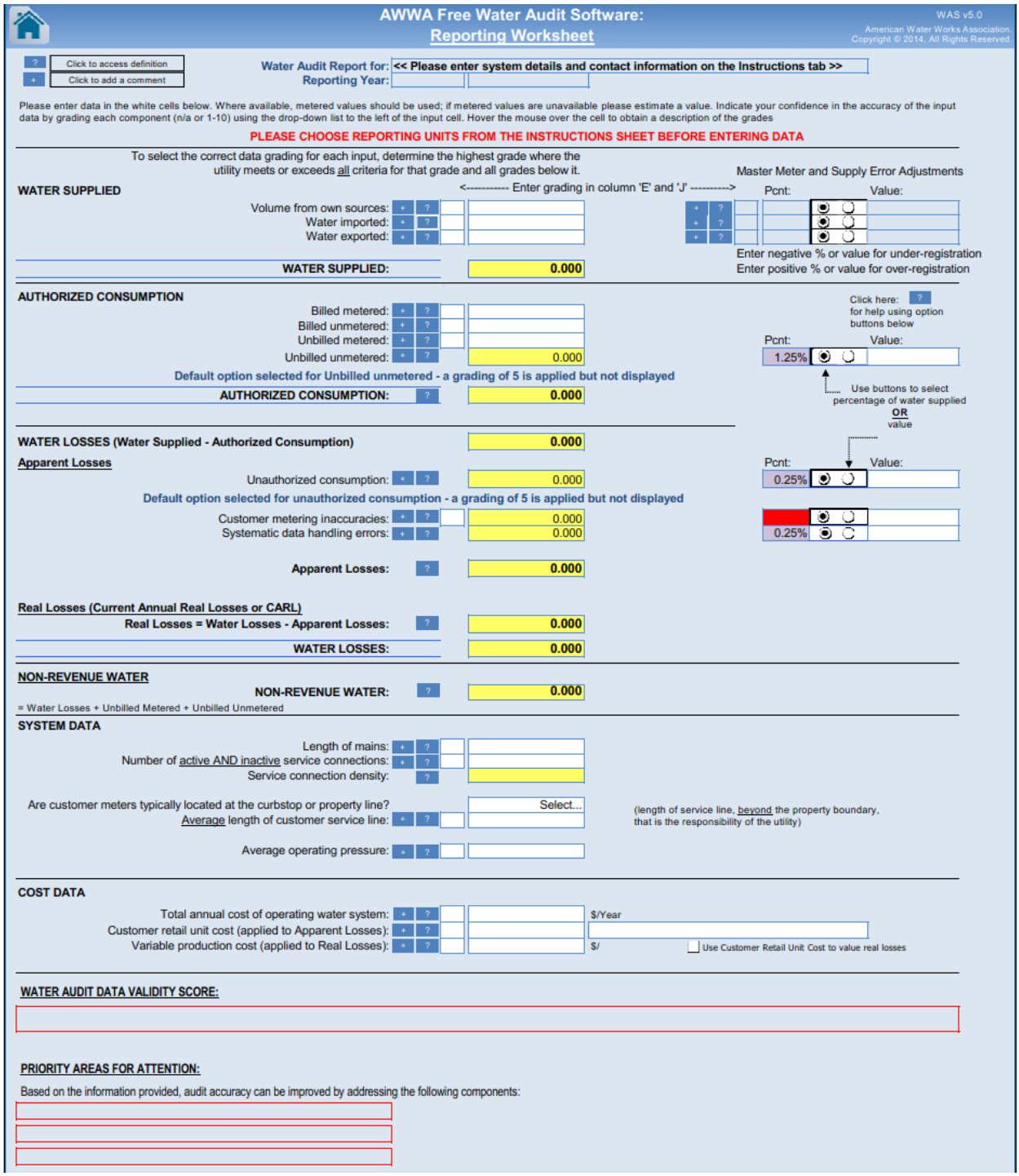
When you have completed filling out the **Instructions** tab, save the file and click on the **Reporting Worksheet** tab. Information you enter in the **Instructions** tab will automatically populate throughout the rest of the Water Audit Workbook.

Note: 1) Volume Reporting Units entered in the **Instructions** tab must be consistent with corresponding entries throughout the **Reporting Worksheet**.

2) You should review the kinds of data requested on the **Reporting Worksheet** and spend some time assembling the information needed to derive each entry.

3.0 INTRODUCTION TO THE REPORTING WORKSHEET

The **Reporting Worksheet**, shown below, is the basis for the water audit. Notice that there are two blue boxes with either a "+" or "?" symbol adjacent to many of the white entry boxes. Clicking the "+" symbol will take you to the **Comments** tab where you can add notes on how the value was determined and document the source. Clicking the "?" symbol will take you to the **Definitions** tab where each term in the **Reporting Worksheet** is defined. The image below is interactive – by clicking on a section of the audit, you will be relocated to the corresponding section of this instruction manual.



To return to the **Reporting Worksheet** page while reviewing this document, click the blue arrow shown at the top right of each page.

3.1 Entering Data in the Reporting Worksheet

The **Reporting Worksheet** allows entry of the data used in the audit. There are five categories of data that are entered in the **Reporting Worksheet**:

- Water Supplied
- Authorized Consumption
- Water Losses
- System Data
- Cost Data

As noted in Section 2.0. be consistent when entering data in the Reporting Worksheet with the Volume Reporting Units entered in the Instructions tab.

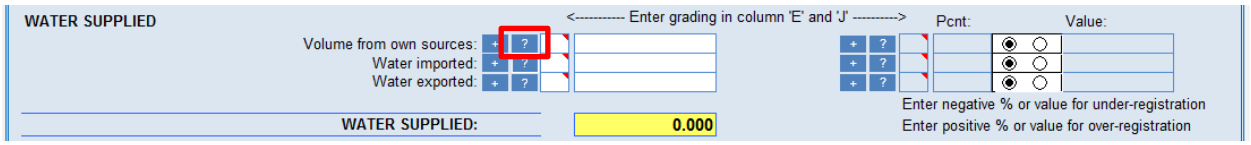
The AWWA water audit procedure was developed to evaluate losses in the potable water (finished water) portion of a system. Non-potable water volumes such as raw water and recycled water should be excluded. A different audit procedure would be applied to raw or recycled water. Only potable water (finished water) volumes should be entered in the spreadsheet.

3.2 Entering a Grading Score in the Reporting Worksheet

The **Reporting Worksheet** also requires the user to numerically "grade" the validity of the data provided for each field. The criteria for each grade can be reviewed by hovering your cursor over the score box. The water audit directions are explicit: **To select the correct data grading for each input, determine the highest grade where the PWS meets or exceeds all criteria for that grade and all grades below.** As an example, if you meet all the criteria for say a six but don't quite achieve all items under an 8, a score of 7 would be selected. Once a grade is selected the **Grading Matrix** tab highlights the assigned grade as well as the recommended future improvement actions. The **Grading Matrix** should be referenced not only to determine how to improve one's score but also for improving water system practices and quality of data collection for subsequent audits. Data grading should be done objectively and critically. Once all data and grades are entered in the **Reporting Worksheet**, a water audit **Data Validity Score** (further discussed in section 11.1) is generated at the bottom of the **Reporting Worksheet**. The **Data Validity Score** is not the summation of all the grades, it is instead the result of a weighted grading structure that takes into account the significance of each value/volume entered into the spreadsheet. It should be noted that utilities performing a water audit for the first time typically receive a total Data Validity Score in the lower or middle range of the matrix.

4.0 WATER SUPPLIED

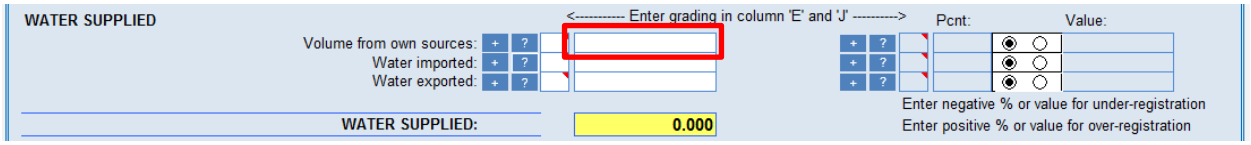
Water Supplied, the volume of water introduced into the distribution system, is determined from three values: **Volume from own sources**, **Volume imported** and **Volume exported**. For each volume, master meter accuracy corrections (error adjustments) should be made to improve the accuracy of the data. To keep the data management as straightforward as possible, volumetric data should be entered as it has been reported and recorded.



The definition of all terms used in the **Reporting Worksheet** are defined in the tab entitled "**Definitions**," which can be accessed for each term by clicking the question mark "**?**" box highlight above. The Water Audit Workbook **Definitions** can also be found in **Appendix B** of this document.

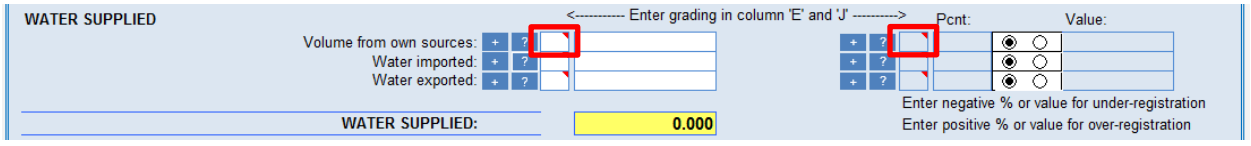
4.1 VOLUME FROM OWN SOURCES

Volume from own sources *is the volume of water withdrawn (abstracted) from water resources (rivers, lakes, wells, etc.) controlled by the water utility, and then treated for potable water distribution. Most water audits are compiled for utility retail water distribution systems, so this volume should reflect the amount of treated drinking water that entered the distribution system* (**Appendix B**). Use data that most accurately represent the actual total volume of water entering the distribution system from the PWS's own supplies (water imported and/or exported will be entered in subsequent boxes). See pages 48-57 of AWWA's Manual 36, 4th Edition, for a detailed discussion of determining **Volume from own sources**.

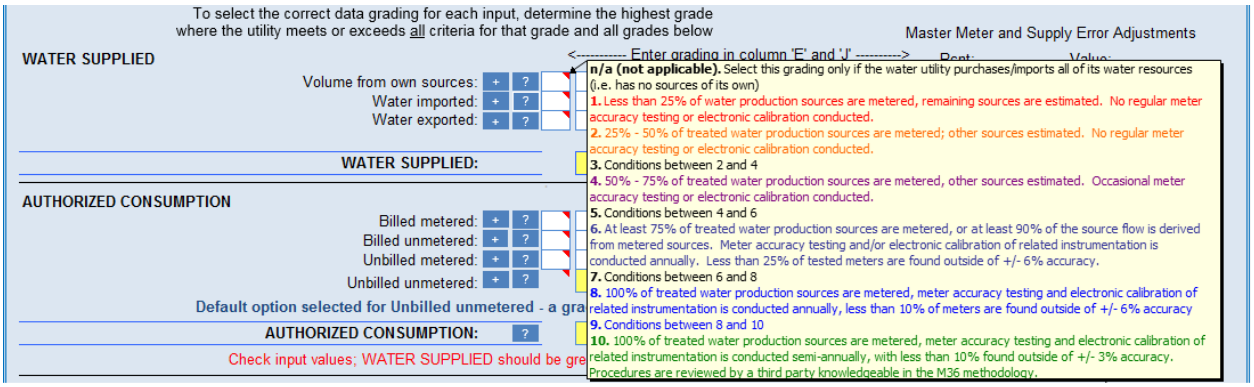


4.1.1 Data Validity

As noted in Section 3.0, the AWWA water Audit Software requires that each data entry be 'graded' or evaluated as to the data's level of accuracy and reliability according to the **Grading Matrix**. This step will be a basis for improving the quality of data collected in the future and subsequent audit results.



Before assigning a score to a particular data entry, the entire range of validity criteria should be reviewed. The criteria for each score can be reviewed by hovering your cursor over the score box.



Data validity should be done objectively and critically. Utilities performing a water audit for the first time typically receive an overall **Data Validity Score** in the lower or middle range of the matrix.

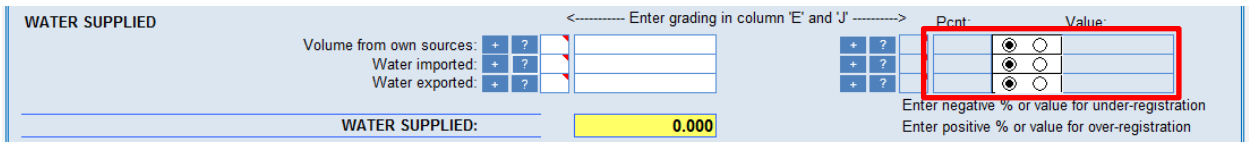
The water audit directions are explicit: **To select the correct data grading for each input, determine the highest grade where the PWS meets or exceeds all criteria for that grade and all grades below.**

Note that data validity must be entered for each value and may differ for each category of **Water Supplied**. If the PWS does not import or export water, then these fields should be left blank.

4.1.2 Error Adjustments

Errors occur during measurement of water flow. If these errors can be identified they should be corrected for in the **Reporting Worksheet**. In particular, meter accuracy testing and calibration information should be used to correct data entered into the **Reporting Worksheet**.

Adjustments based on meter calibration or other identified errors should be made in columns "L" or "N&O" under the **Master Meter and Supply Error Adjustments** section of **Water Supplied**. These corrections may either be expressed as a percent correction ("**Pcnt**"; column "L") or actual volume of correction ("**Value**" columns "N&O"). Although these cells are not shaded white in the image below, once a **Water Supplied** volume is entered into the worksheet, the corresponding **Master Meter and Supply Error Adjustments** row will switch from blue to white.



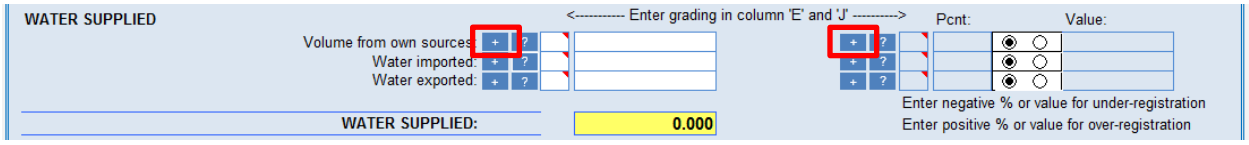
Each PWS has different types of finished water meters, unique testing and calibration procedures based on manufacturer's recommendations, and its own data management processes. As such, the method for calculating meter error must be tailored for each system. Utilities with multiple water treatment plants may find that a different correction procedure is appropriate for each source.

Detailed examples for correcting **Water Supplied** volumes are provided in AWWA M36, pages 51-57. Overall, each PWS should conduct a flow accuracy test, electronic calibration of each meter, and confirm the SCADA system is accurately reading the adjusted metrics.

In addition, water treatment plants typically have piping for sampling, filter backwash, and other water uses that consume or divert water after it enters the potable water distribution system past the finished water meter(s). Evaluation of a schematic drawing of each treatment plant may be useful in determining which connections exist post finished water meter(s) and whether additional metering is appropriate for water services or sample lines that return back into the plant after the finished water meter(s). All connections post finished water meters should be accounted for under one of the categories for **Authorized Consumption** (Section 5.0) of the **Reporting Worksheet**.

4.1.3 Documenting Entered Data

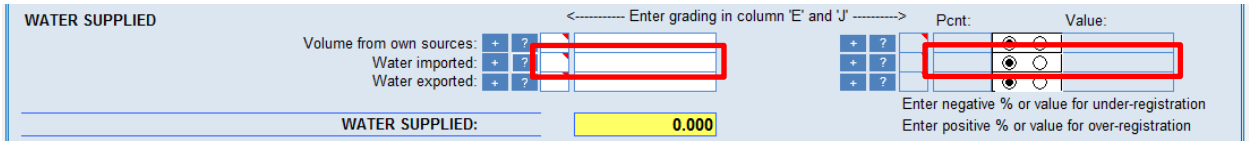
The **Comments** tab allows the PWS to enter *comments or notes to explain how an input value was calculated or to document the sources of the information used* (**Appendix B**). The comments tab can be accessed by clicking the "+" box.



It is important to keep track of data sources, how data entries were calculated or estimated and other pertinent information. For example, the **Comments** tab should be used to document the method used to arrive at the accuracy correction value (Prct or Value) entered for each **Water Supplied** field. Documenting the basis for and calculation of corrections are essential to understanding the audit and demonstrating its validity. This information helps in the interpretation of the water audit results, streamlines future audits, and helps identify areas of improvement.

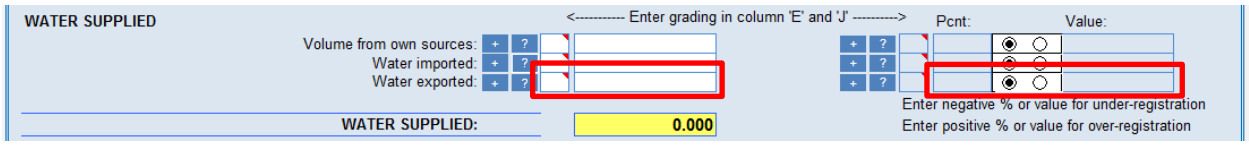
4.2 WATER IMPORTED

Water imported is the *water purchased from a neighboring water utility or regional water authority, and is metered at the custody transfer point of interconnection between the two utilities* (**Appendix B**). Typically, import volume data is metered by the utility selling the water. In many cases the purchasing utility does not receive testing data for the import meters. If your utility imports water, you will need to request the meter calibration and flow testing reports to properly complete the **Water imported** field of the water audit.



4.3 WATER EXPORTED

Water exported is the *bulk water conveyed and sold by the water utility to neighboring water systems that exist outside of their service area* (**Appendix B**). Typically, such sales are metered and are subject to correction based on meter calibration. If the sale is not metered, for example in the case of a temporary or emergency interconnection, the pipe diameter and pressure data can be used to estimate the volume transferred.



Remember to use the same volumetric units entered in the Instructions tab for each category of Water Supplied.

4.4 FINAL NOTE ON WATER SUPPLIED

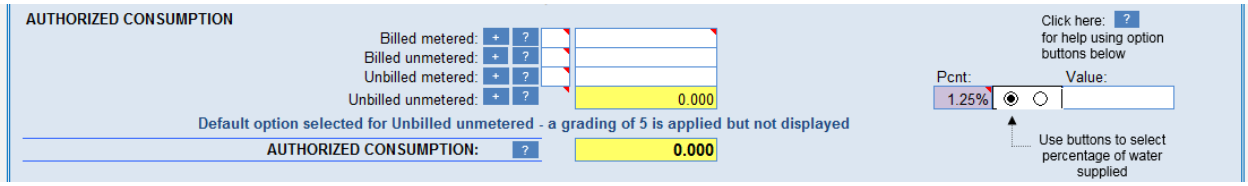
Water Supplied means treated water introduced into the distribution and delivery system that is available to your customer base. The first portion of the **Reporting Worksheet** focuses on water distributed, imported, and water exported. Entering the most accurate data possible for these volumes is important for two basic reasons: 1) they are the largest volumes entered in the worksheet so errors may be magnified in subsequent steps and 2) identifying improvements to data collection and management of water supplied can substantially improve the utilities 'bottom line'.

Before you move on consider the following questions:

- Are <u>all</u> sources of water included (produced and/or purchased)?
- Are <u>all</u> exports of water included?
- Was the data checked to assure that no sources of water were double-counted?
- Are all non-potable water sources excluded?
- Are water meters being flow tested, are all the electrical components being calibrated and is the SCADA registering this info accurately?

5.0 AUTHORIZED CONSUMPTION

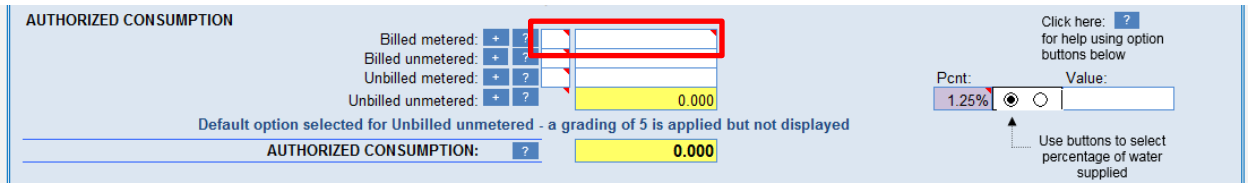
According to the definition used in the AWWA M36, **Authorized Consumption** is the *volume of metered and/or unmetered water taken by registered customers, the water supplier, and others who are authorized to do so* (**Appendix B**). Four (4) categories of **Authorized Consumption** are recognized below (**Billed metered, Billed unmetered, Unbilled metered**, and **Unbilled unmetered**). Volumes are to be provided for each category:



5.1 Billed Metered Consumption

All metered consumption which is billed to retail customers, including all groups of customers such as domestic, commercial, industrial or institutional (**Appendix B**). Reminder, exported water volumes that are not consumed by your customers should be included in "**Water exported**" under the **Water Supplied** section.

Make sure that the parameters of the data compiled for this entry are established such that the consumption data best reflects consumption as it actually occurred within the audit period. Check to see that your comparison of "water in", from the finished water source meters, to "water out", to customers, makes sense. In some cases, a correction is required for differences between the billing period and audit period. It is especially important to make a prorated correction if the PWS bills or reads meters at less frequent intervals, such as bi-monthly or quarterly, and these billing/reading periods do not match up with the audit period. For example, if a utility bills biannually in March and September but the audit period is reviewing volumes from January through December. The readings would need to be prorated for the number of days the billing period falls within the audit period. Another example would be if a portion of meters are billed/read each month to maintain a monthly revenue stream even though a customer may only receive a quarterly bill. It is important to adjust for these situations; subtract water if it was delivered before the audit period and add water if it was delivered after the audit period. See AWWA M36 pages 59-61 for more details and examples to adjust for lead/lag time in meter readings. If feasible, attempt to conduct a system-wide meter read at the beginning and end of your audit period so lead/lag time is not a factor.



If billing per one hundred cubic feet (HCF), remember to convert to million gallons per year (MG/Yr), or other conversion as necessary, to match the Volume Reporting Units selected in the **Introduction** tab.

The data should be actual volumetric usage and for example, should not include changes made to adjust a customer's billing usage for financial reasons. All classes of potable water customers that provide revenue to the utility, including metered construction uses or other temporary customers that generate revenue based on usage, should be included in the **Billed metered** volume.

Review usage database to make sure you do not 'double count'. Be sure any sales to other PWSs or sales of non-potable water are excluded from the data. Sale to another PWS should be included in **"Water exported**" and non-potable water should not be included at all for the M36 process. Metered accounts that are not billed (potentially municipal properties or cemeteries) should be included in the category **Unbilled metered.**

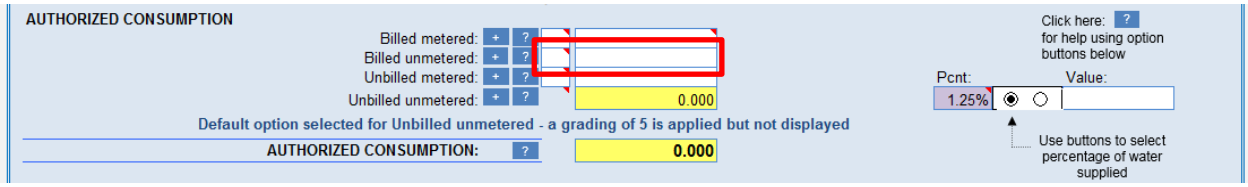
5.1.1 Validity Score

There are several factors to consider when assigning a score to **Billed metered** data:

- Are customer billing records maintained on paper or electronically?
- What is the customer meter read success (or failure) rate?
- What portion of customer meters are read using automatic meter reading (AMR)/advanced metering infrastructure (AMI) technology versus manual reads?
- What is the frequency and scale of estimated reads?
- Are billing records audited? If so, by whom and at what frequency?
- What is the frequency and scale of customer meter testing?
- What guideline, policy, or practice factors into the decision to replace a customer meter?

5.2 Billed Unmetered Consumption

Authorized *billed consumption which is calculated based on estimates or norms from water usage sites that have been determined by utility policy to be left unmetered* (**Appendix B**). The **Billed unmetered** volume is for customers who are charged for water service without metering their actual volume of use. The billing designation is typically a "flat rate" or "fixed fee" since they are charged the same fee for each billing cycle regardless of the consumption volume. **Billed unmetered** consumption also includes estimated reads for problematic accounts where meter installation or replacement is hindered due to customer difficulties. Consumption may be estimated by comparing known uses that are metered or customer's historical usage. The basis for the estimated water use should be provided in the **Comments** section and reflected in the **Grading Matrix** score. Estimation methods should periodically be reviewed and modified if change in ownership or usage conditions change.



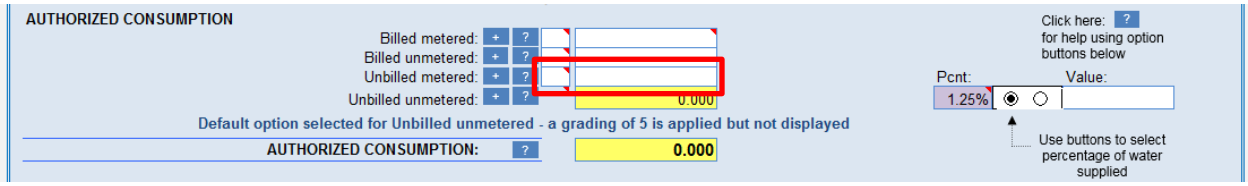
5.2.1 Validity Score

The **Grading Matrix** score should include consideration of:

- What percentage of customers are **Billed unmetered** compared to the total number of customer accounts?
- If the utility's policy is to meter all accounts, which accounts are unmetered due to an exemption versus meter installation difficulty?
- Are the flat rate fees assessed based on reasonable usage estimates that are supported by current information or trends? Are site specific estimates of consumption performed for each account?
- How likely are leaks on the customer's portion of the system to be found? What is the likelihood that they will be reported to the PWS and corrected if unbilled?

5.3 Unbilled Metered Consumption

Metered consumption which is authorized by the water utility, but, for any reason, is deemed by utility policy to be unbilled (**Appendix B**). As a matter of policy, some utilities meter certain users but do not bill those users for the consumption. Examples may include municipal buildings, community parks, cemeteries, street sweeping equipment (filled from a metered source), ballfields, water consumed by the utility, etc. The records of **Unbilled metered** consumption should be reviewed closely since the meters may not be read regularly or may be read on a different cycle than billed meters. Data collected should be managed to avoid double counting if the **Unbilled metered** accounts are included in the PWS billing system reporting. It is also important to review and confirm that every account on the billing exemptions list is an authorized exemption. Some PWS's have found mistakes in the exemptions and usage goes unbilled and/or unreported. Also, if some unbilled accounts are not metered as a result of the billing exemption, the estimated consumption volume should be tabulated under the **Unbilled unmetered** category (discussed in Section 5.4).



5.3.1 Validity Score

Considerations for grading the data validity for **Unbilled metered** consumption include:

- Are there written policies in place identifying specific account billing exemptions? If so, to what degree are the policies adhered to?
- What is the confidence level in an accurate count of **Unbilled metered** accounts?

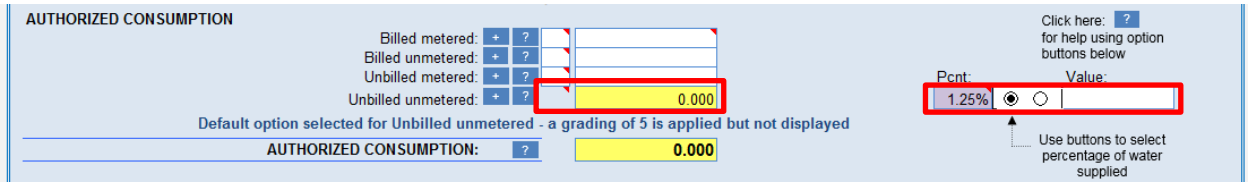
- What is the frequency of meter reading and priority level for meter upkeep?
- If meters are aged and assumed to be inaccurately reading, are consumption volumes estimated or is the meter reading used?

5.4 Unbilled Unmetered Consumption

Any kind of authorized consumption which is neither billed or metered (Appendix B). The volume of Unbilled unmetered consumption is typically determined by estimation or is widely unknown. Unbilled unmetered consumption includes unmetered operational uses by the water utility as well as sewer, DPW, fire and/or highway departments. Depending on a PWS's policies and practices, several Unbilled unmetered uses may include:

- water treatment plant operations (if within boundaries of water audit, i.e. downstream of the finished water meter) including continuously running sample taps, backwash water, water service for sinks and restrooms
- water quality testing
- bleeders and blowoffs throughout the water system
- firefighting and training
- fire flow tests performed by the utility
- customer fire service use and testing
- flushing water mains, storm inlets, culverts, and sewers
- street cleaning, paving, hydrant hookups to wash down vehicles
- landscaping/irrigation in public areas, landscaped highway medians, and similar areas
- public swimming pools, spray parks, and decorative fountains
- drinking fountains
- cemeteries
- public gardens

In many cases, Unbilled unmetered consumption is grossly over or underestimated, especially when a utility does not utilize standard tracking forms or relies on guestimates from other departments. AWWA recommends using the "default" value (1.25% of water supplied) for all utilities.



However, if a utility has carefully documented Unbilled unmetered usage and has a high confidence in the validity of the data, the total estimated volume should be entered in lieu of the default value.

While the PWS may only have crude estimates initially, better data gathering with standardized forms and the consistent use of these forms will significantly improve the accuracy of estimated Unbilled unmetered consumption. It is important to reach out to other departments to determine how to

effectively document and monitor their water usage. Providing forms and training on the use of the forms is highly recommended. In addition, the PWS should consider providing temporary meters or permanently metering Unbilled unmetered uses prior to any subsequent water audits to improve the accuracy and confidence in the audit results.

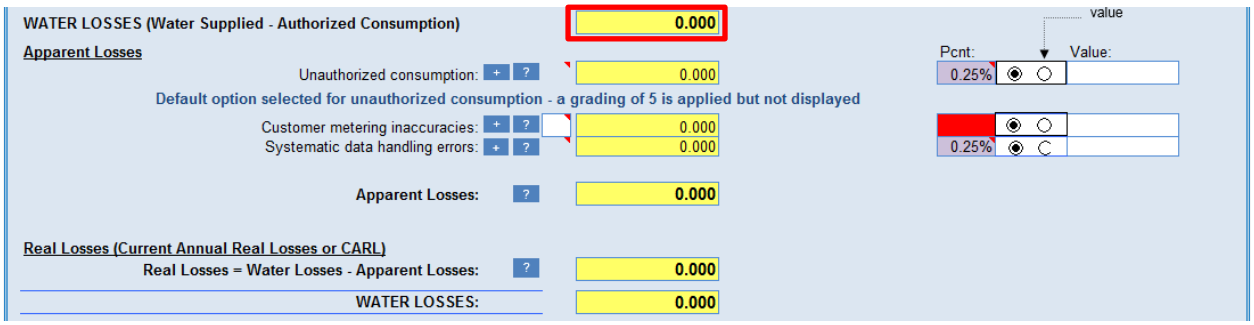
5.4.1 Validity Score

If the default value is used, the data grade is automatically assigned a "5" score. As the PWS develops and implements better data gathering procedures or if the default value was not selected, the following considerations should be used to determine data validity:

- To what degree are Unbilled unmetered uses known?
- To what extent are there policies/procedures in place to track Unbilled unmetered consumption?
- What is the quality of data collection and record-keeping?
- What Unbilled unmetered uses are guesstimated and may need closer evaluation?
- How are Unbilled unmetered consumption volumes quantified (duration and flow rate, known fixed volumes, other methods of estimation)?
- To what extent are the consumption calculations/estimations field verified?

6.0 WATER LOSS

Water Losses are simply calculated as the difference between **Water Supplied** and **Authorized Consumption**. The total volume of **Water Losses** is automatically calculated by the **Reporting Worksheet**.



Water Losses are further broken out into two parts: **Apparent Losses** (further outlined in Section 7.0) and **Real Losses**. **Apparent Losses** are entered into the spreadsheet as default values or estimates calculated by the PWS. **Real Losses** are calculated by the **Reporting Worksheet** as the difference between **Water Losses** and **Apparent Losses**. **Real Losses** are considered unidentified system-wide leaks on mains, services, and storage tanks. Therefore, as the estimate of **Apparent Losses** is improved, a more accurate estimate of **Real Losses** is obtained.

7.0 APPARENT LOSSES

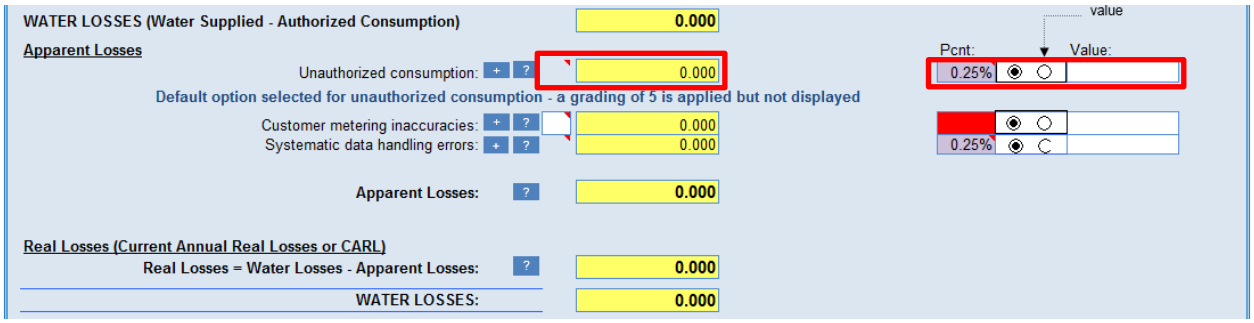
Apparent Losses *include all types of inaccuracies associated with customer metering (worn meters as well as improperly sized meters or wrong type of meter for the water usage profile) as well as systematic data handling errors (meter reading, billing, archiving, and reporting), plus unauthorized consumption (theft of illegal use)* (**Appendix B**). The three components of **Apparent Losses** are called out in the **Reporting Worksheet** as noted below:

- **Unauthorized consumption**
- **Customer metering inaccuracies**
- **Systematic data handling errors**

The value of each is estimated by the PWS or a default value may be used.

7.1 Unauthorized Consumption

Unauthorized consumption *includes water illegally withdrawn from fire hydrants, illegal connections, bypasses to customer consumption meters, or tampering with metering or meter reading equipment; as well as any other ways to receive water while thwarting the water utility's ability to collect revenue for the water.* Losses due to **Unauthorized consumption** (theft of water) are estimated by data available to the PWS or are calculated by AWWA's "default" estimate of 0.25% of **Water Supplied**.



Unauthorized consumption may include:

- Open bypasses or installation of "jumper" piping
- Buried or otherwise obscured meters
- Misuse of fire suppression systems
- Vandalizing or removal of meter registers and/or meter reading components
- Illegally opening intentionally closed valves or curb stops on customer service piping that have been discontinued or shut off for nonpayment
- Connecting to a water main or service (prior to the meter) without the knowledge of the utility
- Connecting to a hydrant without the knowledge of the utility
- Unauthorized removal of an account from the billing system

AWWA has found a default estimate of 0.25% of Water Supplied to be suitable in most cases. However, if a PWS is aware of significant **Unauthorized consumption** and can calculate a reasonable estimate with reliable data, this value should be entered into the "Value" box.

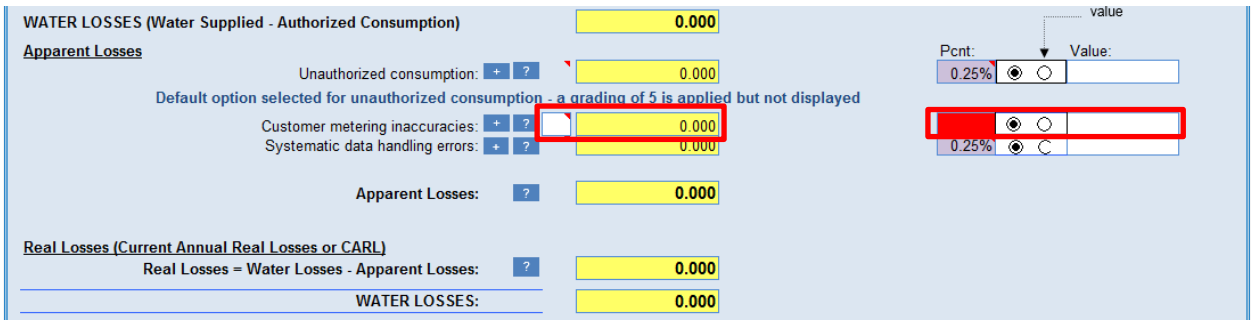
7.1.1 Validity Score

If the default value is used, the score of "5" will automatically be assigned to the data. To help decide whether the default value for Unauthorized consumption is appropriate and to select the appropriate validity score, consider the following:

- What is the level of awareness and extent of theft across the system?
- How is Unauthorized consumption detected?
- Are other agencies (example: police department) employed to assist with identification of theft?
- What policies and procedures are in place to monitor, prevent, and punish theft? To what level are these policies and procedures adhered to?
- What methods of documentation exist and how is the lost consumption estimated?

7.2 Customer Metering Inaccuracies

Apparent water losses caused by the collective under-registering of customer water meters (Appendix B). Customer metering inaccuracies are inaccuracies in registering water consumption by retail customer meters, including meter reading errors, failed reads, and inaccurate meter and data transfer errors. Losses due to metering errors are estimated by data available to the PWS or are calculated by a percent estimate developed by the PWS. See AWWA M36 pages 83-89 for more details and examples of how to quantify Customer metering inaccuracies. The PWS has the option to select a percentage (<10%) or enter a value on the right-hand side for Customer metering inaccuracies.



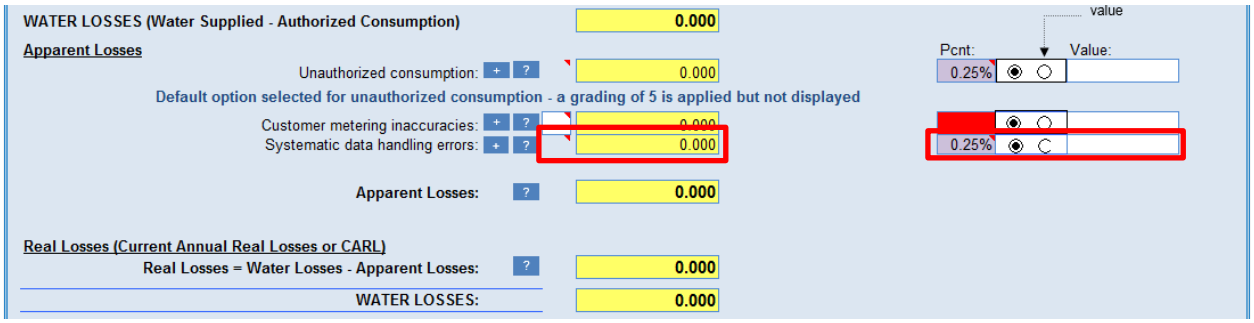
7.2.1 Validity Score

The criteria for grading Customer metering inaccuracies is not the same as for Billed metered consumption. Therefore, the two sets of criteria should be read carefully and the distinctions understood before assigning a grade. Considerations to keep in mind include:

- What is the quality of recordkeeping of customer meters and ability to access data (age, size, type of use, consumption, etc.)?
- What is the extent and frequency of meter testing?
- What is the status of meter replacement program/policies and degree to which the program/policies are strategically designed and implemented?
- By what means are accuracy levels determined?
- Is third party review of customer meter management utilized?

7.3 Systematic Data Handling Errors

Apparent losses caused by accounting omissions, errant computer programming, gaps in policy, and permitting/activation of new accounts; and any type of data lapse that results in under-stated customer water consumption in summary billing reports (Appendix B). Systematic data handling errors include inaccurate estimation of consumption for failed meter read accounts as well as billing adjustments that manipulate the billed consumption to generate a financial credit but does not reflect actual consumption. Basically, any systematic errors from the point of data collection (meter read) through processing the final billing reports. Losses due to Systematic data handling errors are estimated by data available to the PWS or are calculated by AWWA's "default" estimate of 0.25% of Water Supplied.

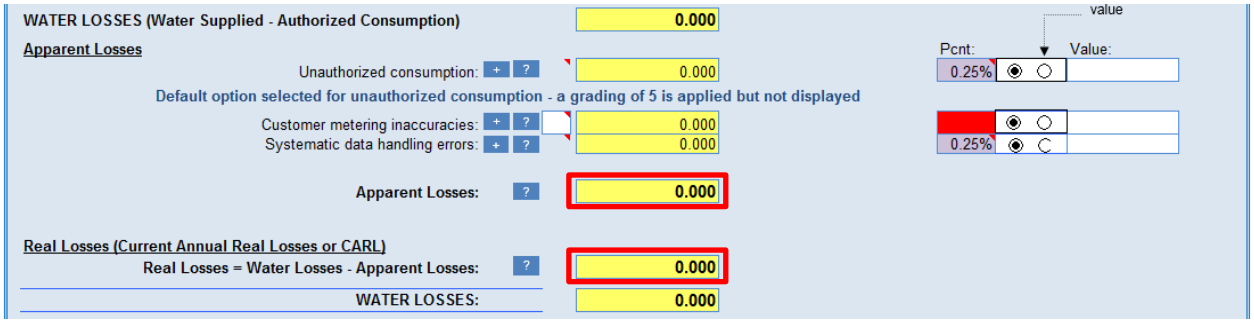


7.3.1 Validity Score

If the default value is used, the score of "5" will automatically be assigned to the data. If a known value can be assigned to Systematic data handling errors, the following grading considerations include:

- How consistent and effective are policies and procedures that govern account activation and billing operations
- What kind of recordkeeping system (computerized or paper records) is used?
- What is the relationship between billing adjustments and measured consumption volumes?
- How effective are water usage estimation procedures?
- What is the frequency and rigor of internal checks on billing accuracy?
- Is third party auditing utilized?

The AWWA Software will automatically sum Unauthorized consumption, Customer metering inaccuracies, and Systematic data handing errors to determine a total volume of Apparent Losses.

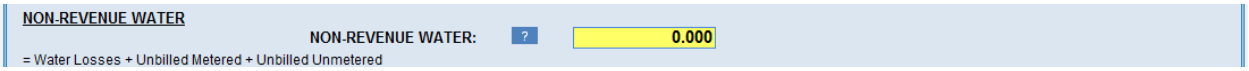


Apparent loss control is important for two main reasons: 1) accurate determination of Real Losses and 2) revenue recovery. Apparent losses are controlled by improvement in areas such as meter reading, customer billing, account management, and customer meter testing and replacement.

Keep in mind: *Any under-estimation of Apparent Losses will result in an over-estimation of Real Losses, and vice versa.*

8.0 NON-REVENUE WATER

Non-revenue water is the portion of the water that a PWS places into the distribution system that is not billed and, therefore, recovers no revenue for the utility. **Non-revenue water** consists of the sum of the following: **Unbilled metered**, **Unbilled unmetered** consumption, **Apparent Losses**, and **Real Losses**. **Non-revenue water** is all potential unrealized revenue related to unbilled consumption losses and all operational losses attributable to system leaks (excess pumping and treatment costs). The **Reporting Worksheet** automatically calculates **Non-Revenue Water**:



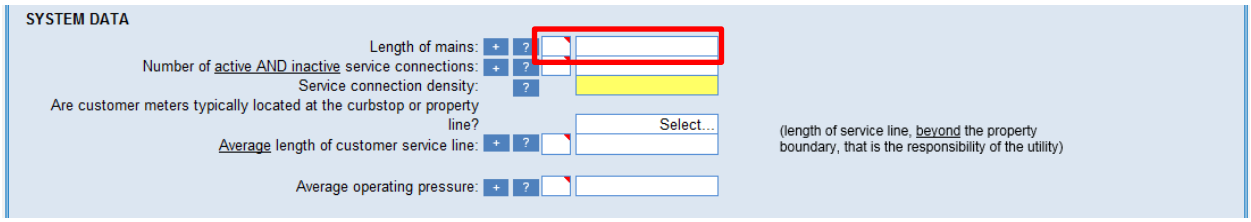
9.0 SYSTEM DATA

System Data includes **Length of mains**, **Number of active and inactive service connections**, **Average length of customer service line**, typical location of customer meters, and **Average operating pressure**. These data inputs, combined with loss information, allow calculation of leakage values that may be used to compare results and document improvement in loss control through subsequent audits.

Distribution system and cost data of the PWS are used to calculate benchmarks that can be used to compare the PWS to other water systems.

9.1 Length of Mains

Input the total length of all water mains within the distribution system (this value should not include raw water transmission mains). The total **Length of mains** includes all pipelines and hydrant laterals but does not include service connections. If the actual length of hydrant laterals is not known, the total length may be estimated by the average lateral length multiplied by the number of hydrants.



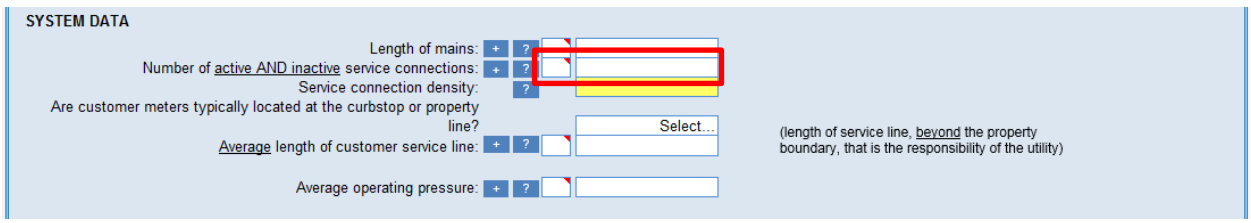
9.1.1 Validity Score

Consider the following when scoring the validity of the **Length of mains** data:

- What is the established policy and procedure to document, permit, and commission new water main installations or abandonment of existing (parallel) water mains?
- What type of recordkeeping (paper records, GIS, asset management database) is used?
- What is the quality of recordkeeping and frequency that records are updated?
- How frequently does field validation occur, and what are the results?

9.2 Number of Active and Inactive Service Connections

This is the total number of connections to the distribution system and includes all distinct piping connections from the main to the customer, including fire service connections, regardless of whether or not the service connection is metered or whether any related account is active or inactive. **This number is typically different from the number of customers or accounts.**



9.2.1 Validity Score

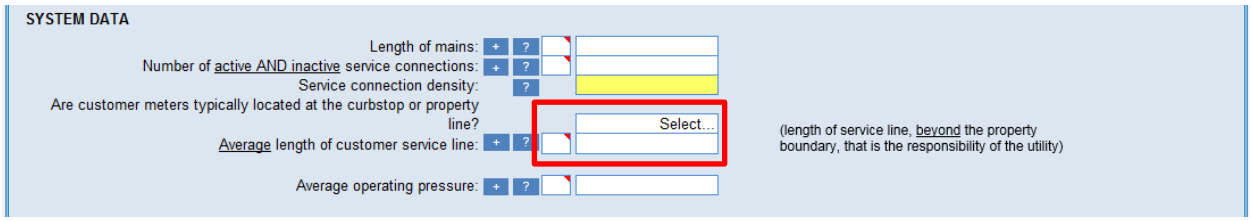
In assigning a grade to this data, both the history and nature of data management are important:

- How strong is the application permitting policy for new service connections?
- To what extent is permitting enforced and how is oversight implemented in permitting?
- What type of recordkeeping (paper records, GIS, asset management database) is used?
- What is the quality of recordkeeping and frequency that records are updated?
- How frequently does field validation occur; what are the results?

Once the **Length of mains** and **Number of active and inactive service connections** are added, the **Service connection density** value (number of customer service connections divided by the total length of mains) is calculated automatically by the **Reporting Worksheet**. This value is used by the software to generate **Performance Indicators** which are discussed in greater detail in Section 12.0.

9.3 Location of Customer Meters and Average Length of Customer Service Line

The location of the meter is input as a yes or no answer to the question "are customer meters typically located at the curb stop or property line?" If for example all meters in the system are installed in meter pits located at the property line, a "Yes" answer would be selected. When a "Yes" answer is selected, the **Average length of customer service line** is set to zero and the grading component automatically populates to 10. For this scenario, any leaks or breaks that occur on the customer's side of the service line would be metered (and typically billed), therefore, per M36, not considered a water loss to the utility. However, most PWSs in Massachusetts install meters at or inside the customer's building and therefore would select "No". The **Average length of customer service line** owned and maintained by the customer from the point of ownership transition (typically the water main, property line or curb stop) to the meter should be determined. A diagram of different customer service line configurations can be referenced by clicking on the **Service Connection Diagram** tab of the audit software.



9.3.1 Validity Score

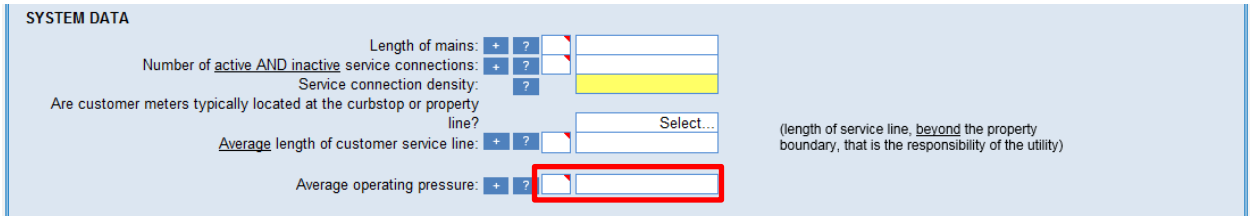
If the response to this question was "Yes", then an automatic grading of 10 is applied. If the response was "No", then you will need to assign a data validity and consider the following:

- How clear is the policy governing delineation of PWS versus customer ownership of service connection piping?
- What is the basis for estimating average length of piping: approximation based on a limited number of field measurements, well documented service tie cards, statistically valid number of field checks, GIS?

- What is the quality of recordkeeping and frequency that records are updated?
- How frequently does field validation occur and what are the results?

9.4 Average Operating Pressure

This value should be derived from actual field measurements or a calibrated hydraulic model and should include consideration of the range of variations seen throughout a full daily cycle. If the Average operating pressure is estimated from less substantial information, the validity score should be low.



9.4.1 Validity Score

Considerations for grading include:

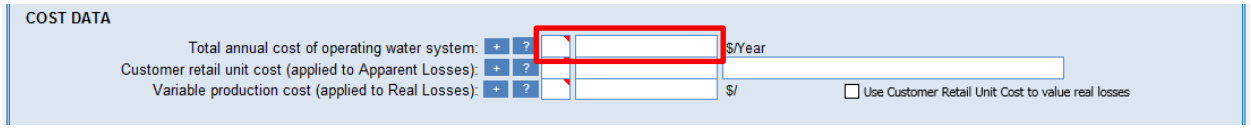
- What are the means of gathering and the accuracy of pressure data?
- How is the system setup to manage/maintain pressure?
- How is pressure monitored throughout the system?
- What is the quality of pressure zone management / discreteness of pressure zones (i.e. reliability of maintaining pressure in each zone)?
- How frequently does field validation occur and what are the results?

10.0 COST DATA

Cost data are used to estimate the unit cost of both **Apparent Losses** and **Real Losses**. These estimates show the value of water loss control efforts and help motivate the PWS in its loss control efforts.

10.1 Total Annual Cost of Operating Water System

Costs include those for operations, maintenance, and any annually incurred costs for long-term upkeep of the drinking water supply and distribution system. It should include the costs of day-to-day upkeep and long-term financing such as repayment of capital bonds for infrastructure expansion or improvement as well as *salaries and benefits, materials, equipment, insurance, fees, administrative costs,* and all other operational and maintenance costs (**Appendix B**). In many cases budgets are created based on a fiscal year. The PWS should review the two fiscal years that overlap with the audit calendar year to determine the **Total annual cost of operating water system** value.



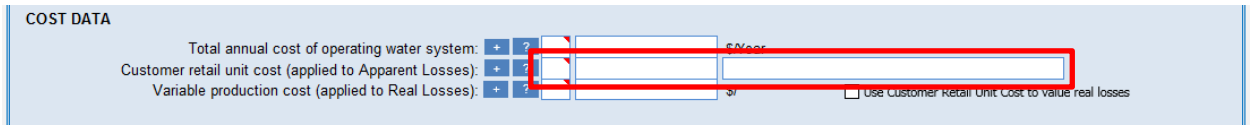
10.1.1 Validity Score

Considerations for the data validity include:

- What type of accounting system (paper, electronic) is used?
- How reliable and thorough is the accounting system?
- How frequently do financial audits occur and how rigorous are the audits?

10.2 Customer Retail Unit Cost

Customer retail unit cost is the unit charge for water delivered to the customer. Typically, it is the cost per volumetric unit of water. It does not include any fixed charges (i.e. meter maintenance or service line size changes) nor should it include separate charges for sewer or stormwater services if they are not directly associated with the water consumption rate charge. If there is one rate charged to all customer classes (a.k.a. use categories), no matter the volume of consumption, the **Customer retail unit cost** is an easy data entry. If there is an individual rate charged per customer class, then the weighted average of the individual rates based on the number of customers per class should be calculated and entered in the spreadsheet. In many cases, PWSs bill customers based on an increasing block rate. To calculate the **Customer retail unit cost** for an increasing block rate structure, take the weighted average of the individual rates based on either the volume or revenue realized across the audit period for each rate. One of the simplest ways to estimate **Customer retail unit cost** for an increasing block rate structure is to divide the total revenues (that are based on volumetric billing) by the total volume of potable water sold.



Don't forget to select the correct volumetric unit used in developing the unit cost.

The **Customer retail unit cost** value is applied to **Apparent Losses** by the software to identify the potential revenue lost for these losses. By reducing **Apparent Losses**, the utility is able to capture more revenue at the retail rate.

10.2.1 Validity Score

In assigning a grade to this data, factors to consider are:

- To what degree do the billing operations accurately reflect rate structure?
- By what means is the composite **Customer retail unit cost** calculated?
- How effective is the water rate structure in providing adequate revenue to maintain and operate the water system?
- What are the auditing procedures for water rates and customer classes?

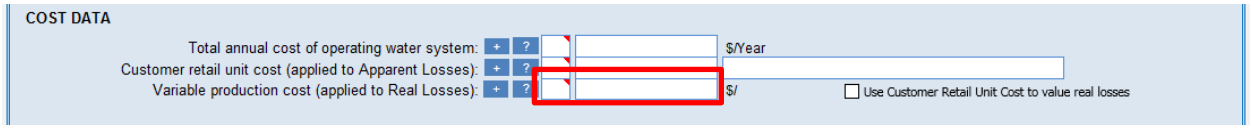
10.3 Variable Production Cost

Variable production cost is the cost to produce and supply water to the distribution system. Since each PWS has a unique combination of sources (groundwater and/or surface water) and treatment methods associated with each, calculating the **Variable production cost** may be complex. The goal is to consider any costs that would be reduced if less water was produced and distributed. Examples of **Variable production costs** include:

- Energy (propane, natural gas, electric, etc.) to power, heat, and pump the treatment and pump station facilities
- Chemicals
- Costs associated with importing water
- Removal and disposal of drinking water residuals

More complex factors that may be considered include: reviewing costs associated with the most expensive (or marginal) source, the costs associated with avoiding expansion of supply (if losses are controlled), liability, and wear and tear on equipment.

The AWWA software is set up such that the **Variable production cost** will be reported in whichever unit was selected for **Volume Reporting Units** in the **Instructions** tab.



Make sure that the units for each cost are properly taken into account based on the duration of the audit period when performing calculations.

The Variable production cost value is applied to Real Losses to identify the potential cost savings as Real Losses are eliminated.

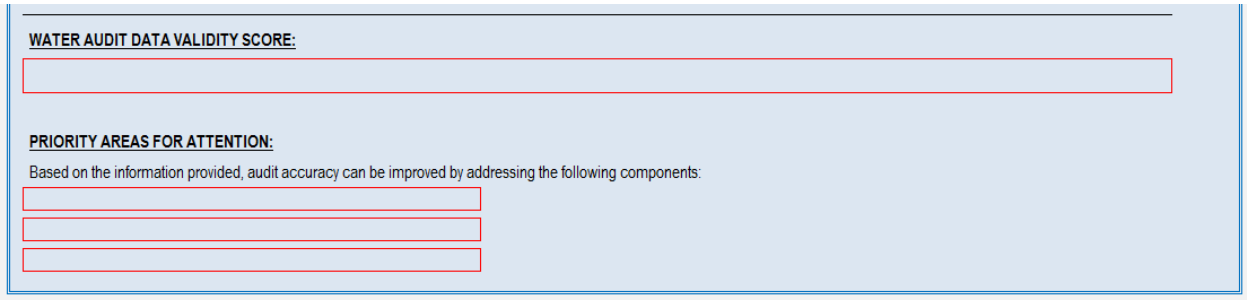
10.3.1 Validity Score

Considerations for the data validity include:

- What type of accounting system (paper, electronic) is used?
- How reliable is the accounting system?
- How thorough is the allocation of cost (whether indirect or secondary costs are included)?
- How frequently do audits occur and how rigorous are the audits?

11.0 WATER AUDIT RESULTS

Upon completion of all data entry, the **Reporting Worksheet** automatically calculates a **Data Validity Score (DVS)** and lists the top three "**Priority Areas for Attention**". These parameters are located at the bottom of the worksheet. If the auditor has a high degree of confidence in the data entered, the **DVS** indicates the quality of the audit and the **Priority Areas for Attention** highlight areas of recommended improvement.



11.1 Water Audit Data Validity Score

The **Data Validity Score (DVS)** indicates the overall reliability and trustworthiness of the water audit results. As a reminder, the DVS is not a summation of the grades entered for each data set. It is the result of a weighted grading structure that takes into account the significance of each value/volume entered. The score may be improved in future audits by implementing measures suggested in the **Grading Matrix**. The matrix provides specific guidance for improving quality of data entered into each element of the **Reporting Worksheet**. The **DVS** is also used to help identify functional focus areas identified in the **Water Loss Control Planning Guide** (See **Loss Control Planning** tab). The **Water Loss Control Planning Guide** establishes five ranges of **DVS** (Levels I through V, with numerical ranges from 0-100) to designate specific action items with corresponding functional focus areas for varying **DVS** scores. The five potential functional focus areas are:

- Audit data collection
- Short-term loss control
- Long-term loss control
- Target-setting
- Benchmarking

In all cases, the PWS should focus on the reliability and completeness of data entered in the water audit. As the source and accuracy of the data is further understood and verified, a PWS may choose to pursue additional functional focus areas.

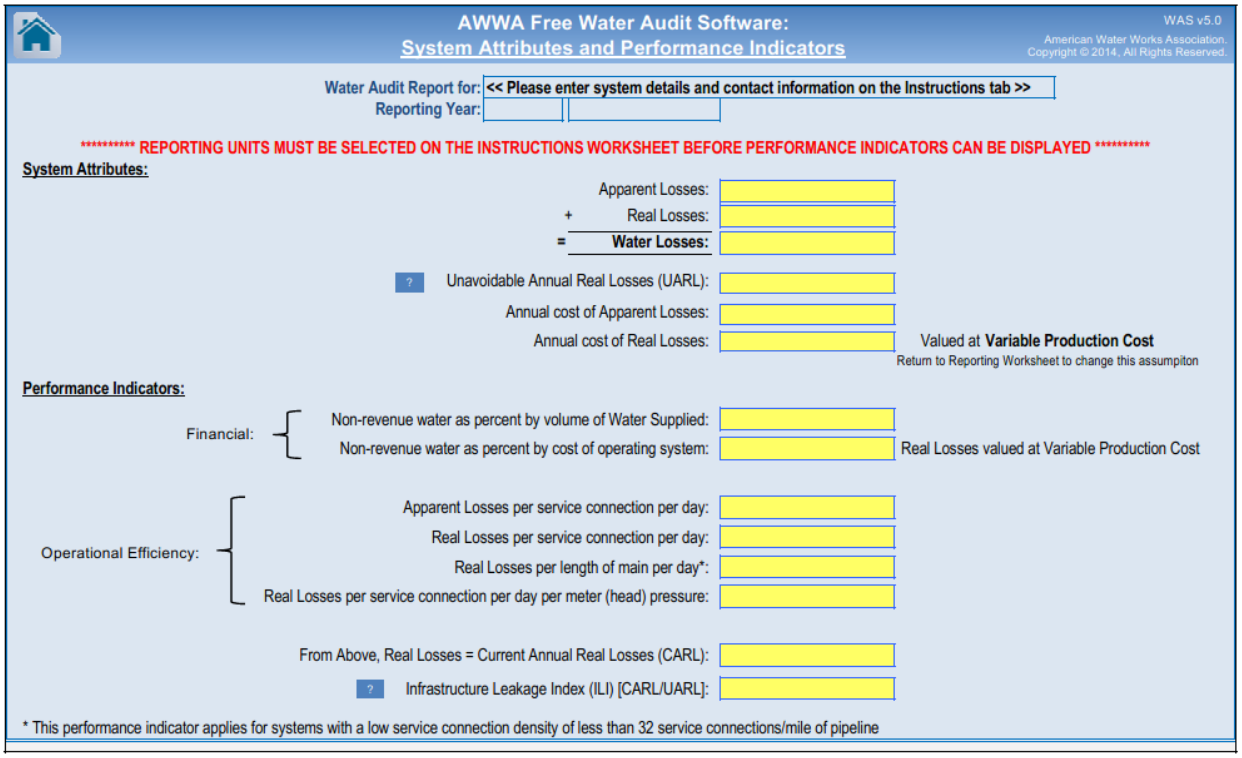
11.2 Priority Areas for Attention

Based on the data entered and associated grade, the audit software calculates three specific areas for review to improve data validity. These suggested **Priority Areas for Attention** should be evaluated carefully. Focusing on these areas will result in a better **Data Validity Score**, but will not necessarily be the best way to control water losses. Improved data validity may also be achieved while implementing specific methods to control losses. If the **Priority Areas for Attention** differ with specific

concerns and goals of the PWS, careful evaluation of the costs and benefits associated with each course of action should be considered.

12.0 PERFORMANCE INDICATORS

The AWWA water audit software produces several metrics that relate to the quality of the data used and controlling losses. The results may be used to guide better data collection, focus water loss control efforts, measure improvement across subsequent audits, and compare results against similar utilities. These results or "Performance Indicators" are located on the Performance Indicators tab. The calculation and use of Performance Indicators is what sets the AWWA M36 methodology apart from other types of water audits. Additional information on the relationship between data entered and the Performance Indicators is provided in the AWWA M36 manual (pages 105-109). This section will provide a summary of the various Performance Indicators and their usefulness. The image below is interactive – by clicking on a section of the Performance Indicators, you will be relocated to the corresponding section of this instruction manual.



Performance Indicators relate to distribution system performance during the audit period. They are derived from the data entered into the water audit and are not changed by the individual data validity grading. However, low data validity may impact the accuracy of the data and therefore the applicability of these indicators. The indicators rely on system attributes calculated from data entered in the Reporting Worksheet. The calculated system attributes are:

- Unavoidable Annual Real Losses (UARL)
- Annual cost of Apparent Losses
- Annual cost of Real Losses

To return to the Performance Indicators page while reviewing this section of the document, click the red arrow shown at the top left of each page.

UARL is a reference value and does not refer to a specific type of leakage occurring in the water distribution system. *The UARL is a theoretical reference value representing the technical low limit of leakage that could be achieved if all of today's best technology could be successfully applied. Striving to reduce the system leakage to a level close to the UARL is usually not needed unless the water supply is unusually expensive, scarce or both* (Appendix B). Calculation of the UARL is detailed on the Definitions tab and on page 103 of the AWWA M36. It includes factors derived from water utilities and uses the following audit data inputs: Length of mains, Average operating pressure, Average length of customer service line, and Number of active and inactive service connections.

> **Note:** For smaller systems or systems with an Average operating pressure less than 35 psi, AWWA's M36 indicates the UARL value may not be valid. Therefore, the spreadsheet will not display UARL or Infrastructure Leakage Index (discussed in Section 12.8) values.
>
> M36 defines a smaller system if the following calculation is valid: (Length of mains in miles x 32) + Number of service connections < 3,000.

Annual cost of Apparent Losses is calculated by multiplying the Apparent Losses by the Customer retail unit cost. It is a measure of the potential value of lost revenue attributed to Apparent Losses. Annual cost of Real Losses is calculated by multiplying the Real Losses by the Variable production cost. It is a measure of additional costs associated with pumping and treating excess water attributed to Real Losses. Annual cost of Apparent Losses and Annual cost or Real Losses are used to calculate the following additional Performance Indicators:

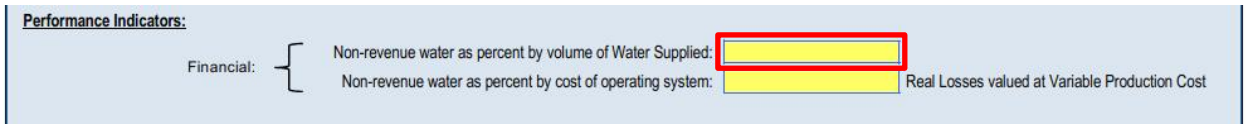
- Financial Indicators
  - Non-revenue water as percent by volume of Water Supplied
  - Non-revenue water as percent by cost of operating system
- Operational efficiency
  - Apparent Losses per service connection per day
  - Real Losses per service connection per day (for system density > 32 connections/mile)
  - Real Losses per length of main per day (for system density < 32 connections/mile)
  - Real Losses per service connection per day per psi pressure
- Medium and Large System Performance Indicators
  - Current Annual Real Losses (CARL)
  - Infrastructure Leakage Index (ILI)

Each indicator above has its advantage when applied properly but also has its limitations. Each Performance Indicator is discussed in more detail below.

12.1 Non-Revenue Water as Percent by Volume of Water Supplied

This is a financial indicator that calculates the percentage of the volume of Non-Revenue Water over the Water Supplied volume. It is useful to assess overall water supply management on a financial

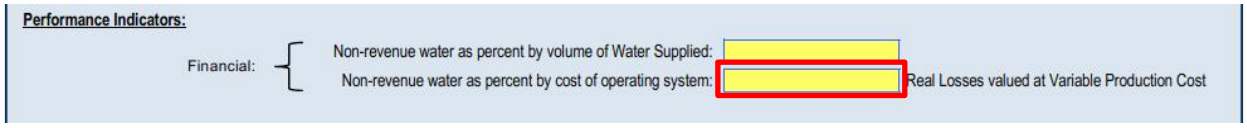
basis. It is also typically the closest **Performance Indicator** to MassDEP's unaccounted for water (UAW) estimation.



Non-revenue water as a percent by volume of Water Supplied does not provide specific insight to the level of apparent loss or real loss management. The percentage is skewed by varying levels of customer consumption and it is not useful as an operational **Performance Indicator**. As a result, AWWA recommends that it should not be used for year-to-year operational performance tracking.

12.2 Non-Revenue Water as Percent by Cost of Operating System

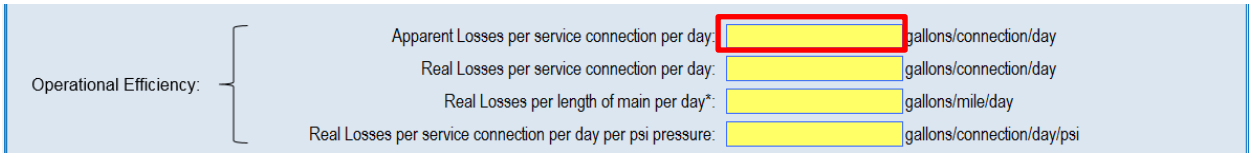
This is a financial indicator that calculates the value of **Non-Revenue Water** as a percentage of the total cost to operate the water system.



It measures the cost of both apparent and real losses plus water taken from the system without payment (theft, non-metered deliveries etc.). **Non-revenue water as percent by cost of operating system** is not particularly useful as a year-to-year measurement and should be used more for evaluating ongoing financial performance. However, as it reveals the financial impact of water loss, it provides important cost insight for utility managers, customers, and regulators for the audit period, especially in comparison to the **Non-revenue water as a percent by volume of Water Supplied**.

12.3 Apparent Losses Per Service Connection Per Day

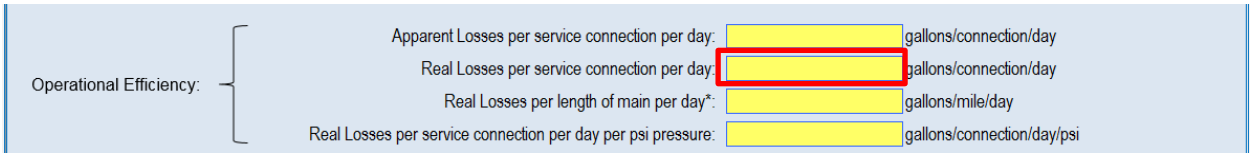
This indicator helps assess the impact of apparent loss reduction and is useful for tracking improvement in controlling **Apparent Losses** on a year-to-year basis. If apparent loss controls are successful, a downward trend in this measure should be observed.



12.4 Real Losses Per Service Connection Per Day

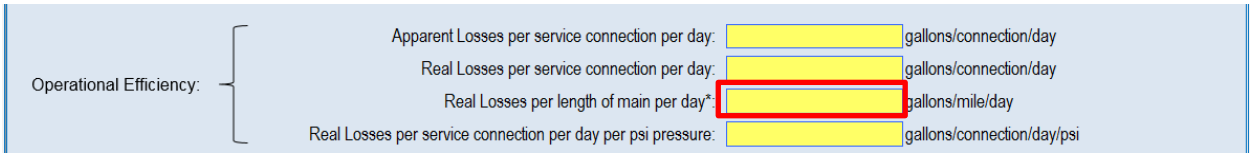
This indicator is useful for comparing changes in **Real Losses** and for basic target-setting. As leakage management controls are successfully implemented, a downward trend in this measure should be observed. This indicator is only calculated by the software for systems with an average

density greater than 32 service connections per mile. If the density is less than 32 service connections per mile, skip down to the next line, **Real Losses per length of main per day**.



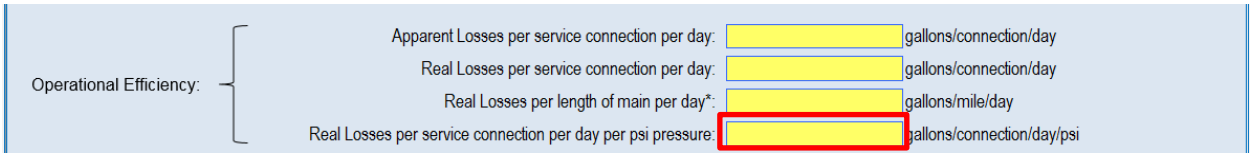
12.5 Real Losses Per Length of Main Per Day

This indicator is useful for comparing changes in **Real Losses** and for basic target-setting. As leakage management controls are successfully implemented, a downward trend in this measure should be observed. This indicator is only calculated by the software for systems with an average density less than 32 service connections per mile.



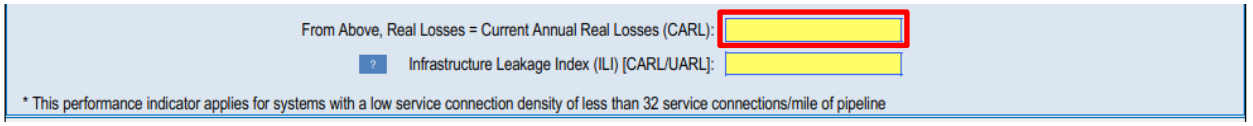
12.6 Real Losses Per Service Connection Per Day Per PSI Pressure

This indicator is useful for comparing changes over time in a system. However, as it is pressure sensitive, it is not useful for comparison to other systems. The software only calculates a value for systems whose connection density is greater than 32 connections per mile. Smaller systems will need to manually calculate this **Performance Indicator** by dividing the **Real Losses per length of main per day** indicator by the **Average operating pressure**.



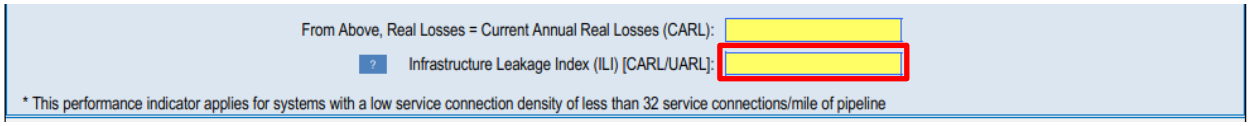
12.7 Current Annual Real Losses (CARL)

The **CARL** is the volume of water loss from reported leaks (not including leaks found during leak detection surveys), unreported leaks, background losses, and storage tank overflows. The software equates the **CARL** to **Real Losses** and calculates the **Infrastructure Leakage Index** by taking the ratio of the **CARL** to **UARL**.



12.8 Infrastructure Leakage Index (ILI)

The ILI compares the actual volume of Real Losses to the theoretical lowest possible volume of leakage that can be technically achieved for a water system. In simpler terms, the ILI is *the ratio of Current Annual Real Losses (CARL) to Unavoidable Annual Real Losses (UARL)* (Appendix B).



This indicator is highly effective for comparisons to other systems. However, its usefulness depends on sufficient water audit data validity and implementation of pressure management. In addition, it may not be valid for small systems or those operated at low pressure if the UARL (Section 12.0) is not calculated by the software. ILI values are useful for preliminary leakage targets, but should not be relied on long-term as changes in pressure will alter the UARL and accordingly the ILI. Use of the ILI should be limited to initial water auditing and leakage control analysis for lower level audits. For higher level audits, typically Level III or greater, the ILI is a great benchmarking performance indicator.

END OF INSTRUCTIONS

APPENDIX A

Example Data Collection Sheet

Example Data Collection Sheet - AWWA M36 Audit Methodology

Data Inputs (MG/Yr unless otherwise noted)		Example of Data Inputs/Discussion Points
Calendar Year:	2016	**Note: if customer water meters are NOT read Late December/early January, provide last 2015 and first 2017 reads as well to adjust for meter read lead/lag time**
Start/End Date:	Jan 1-Dec 31	

Water Supplied:

Volume introduced into the distribution system from all PWS Source(s)	Please list volumes metered from each source, list type of meter(s) used for each source, and provide method(s) for determining volumes
Master meter error adjustment (%)	Provide frequency and method of testing and calibration and % error determined
Water volume imported from outside sources	Provide the volume of any finished water purchased during the calendar year and introduced directly into the distribution system Provide method(s) for determining volumes, frequency and method of testing and calibration, and % error determined
Water volume exported to outside sources	Any finished water sold/delivered outside of system not billed to customers Provide method(s) for determining volumes, frequency and method of testing and calibration, and % error determined
Change in distribution system storage: Jan 1 versus December 31	Based on the difference in storage volumes at start and end of audit period

Authorized Consumption:

Billed Metered (billed based on metered water use)	Any metered usage that is billed Provide types of meters and reading system(s) and information on how data is transferred into the billing system Are there estimates made for failed meter reads?
Billed Unmetered	Flat/fixed fee or method of calculating bills for these types of users. If different billing fee methods, provide a breakdown of how many meters are associated with each fee method
Unbilled Metered	These are customers or accounts that are not billed but are metered Based on PWS policies, these may include municipal accounts, parks or ballfields, cemeteries
Unbilled Unmetered	Fire fighting/training, flushing/flow testing, general maintenance (water and/or sewer system), bleeders, leak detection survey, water main/service breaks, tank overflows, tank draining for maintenance, construction/hydroseeding usage, faulty equipment (surge/pressure valves discharging to atmosphere and not recycled back into system, etc.), recycled water post source meter, other
Customer Meters	What are the testing procedures for residential and large meters in your system? Do you have a meter replacement program?

Data Inputs (MG/Yr unless otherwise noted)	Example of Data Inputs/Discussion Points
Apparent Losses:	
Unauthorized consumption	Theft (illegal connections, meter tampering, etc.) Provide method of calculating
Customer metering inaccuracies	Losses calculated and/or how are they documented? How are disputes resolved?
Systematic data handling errors	What internal controls exist for data collection, entry, and archiving? How are billing system errors handled?
System Data:	
Length of mains (mile)	Method of record keeping (paper, electronic, GIS) What is the condition and replacement schedule for mains (sound policy in place)?
Number of active AND inactive service connections	Briefly describe installation and abandonment methods/record keeping (paper, electronic, GIS)
Average length of customer service line (ft.)	Please estimate the average distance from the transition point between the PWS & customer service line boundary to the meter (typically the length from the curb stop to meter) What part of the service line is the PWS responsible for? Where are the meters located (meter pits, in customer's building, etc.)?
Average operating pressure (psi)	Provide a system-wide average operating pressure. Is the system divided into pressure zones and if so how is pressure monitored/estimated (topo maps, data loggers, pressure sensors/static gauges, periodic calibration of hydraulic model, extent of SCADA)?
Cost Data:	
Total annual cost of operating system ($)	What cost factors are included? If operating budget is based on the fiscal year average two fiscal years for the audit calendar year What is the basis of the various cost factors and how are they tabulated? Are industry-standard cost accounting systems in place?
Customer retail unit costs ($/gal, $/cu.ft., or $/unit)	Please provide the rate structure (increasing block, fixed fee). How frequently are rates reviewed for effectiveness? Are water rates straightforward to apply and consistent in all cases? What policies are in place to adjust the rates?
Variable production cost ($/MG)	Primary operating functions such as electric and treatment costs that change depending on how much water is produced and delivered. How are these tabulated? What additional costs (liability, residuals management, etc.) are included?

APPENDIX B

Definitions
(Directly from the Definitions tab of the Water Audit Workbook)

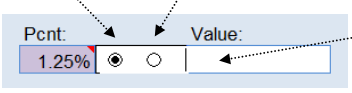
AWWA Free Water Audit Software: Definitions

WAS v5.0

Item Name	Description
Apparent Losses Find	= unauthorized consumption + customer metering inaccuracies + systematic data handling errors Apparent Losses include all types of inaccuracies associated with customer metering (worn meters as well as improperly sized meters or wrong type of meter for the water usage profile) as well as systematic data handling errors (meter reading, billing, archiving and reporting), plus unauthorized consumption (theft or illegal use). NOTE: Over-estimation of Apparent Losses results in under-estimation of Real Losses. Under-estimation of Apparent Losses results in over-estimation of Real Losses.
AUTHORIZED CONSUMPTION Find	= billed water exported + billed metered + billed unmetered + unbilled metered + unbilled unmetered consumption The volume of metered and/or unmetered water taken by registered customers, the water utility's own uses, and uses of others who are implicitly or explicitly authorized to do so by the water utility; for residential, commercial, industrial and public-minded purposes. Typical retail customers' consumption is tabulated usually from established customer accounts as billed metered consumption, or - for unmetered customers - billed unmetered consumption. These types of consumption, along with billed water exported, provide revenue potential for the water utility. **Be certain to tabulate the water exported volume as a separate component and do not "double-count" it by including in the billed metered consumption component as well as the water exported component.** Unbilled authorized consumption occurs typically in non-account uses, including water for fire fighting and training, flushing of water mains and sewers, street cleaning, watering of municipal gardens, public fountains, or similar public-minded uses. Occasionally these uses may be metered and billed (or charged a flat fee), but usually they are unmetered and unbilled. In the latter case, the water auditor may use a default value to estimate this quantity, or implement procedures for the reliable quantification of these uses. This starts with documenting usage events as they occur and estimating the amount of water used in each event. (See Unbilled unmetered consumption)
View Service Connection Diagram **Average length of customer service line** Find	This is the average length of customer service line, Lp, that is owned and maintained by the customer; from the point of ownership transfer to the customer water meter, or building line (if unmetered). The quantity is one of the data inputs for the calculation of Unavoidable Annual Real Losses (UARL), which serves as the denominator of the performance indicator: Infrastructure Leakage Index (ILI). The value of Lp is multiplied by the number of customer service connections to obtain a total length of customer owned piping in the system. The purpose of this parameter is to account for the unmetered service line infrastructure that is the responsibility of the customer for arranging repairs of leaks that occur on their lines. In many cases leak repairs arranged by customers take longer to be executed than leak repairs arranged by the water utility on utility-maintained piping. Leaks run longer - and lose more water - on customer-owned service piping, than utility owned piping. If the customer water meter exists near the ownership transfer point (usually the curb stop located between the water main and the customer premises) this distance is zero because the meter and transfer point are the same. This is the often encountered configuration of customer water meters located in an underground meter box or "pit" outside of the customer's building. The Free Water Audit Software asks a "Yes/No" question about the meter at this location. If the auditor selects "Yes" then this distance is set to zero and the data grading score for this component is set to 10. If water meters are typically located inside the customer premise/building, or properties are unmetered, it is up to the water auditor to estimate a system-wide average Lp length based upon the various customer land parcel sizes and building locations in the service area. Lp will be a shorter length in areas of high density housing, and a longer length in areas of low density housing and varied commercial and industrial buildings. General parcel demographics should be employed to obtain a composite average Lp length for the entire system. Refer to the "Service Connection Diagram" worksheet for a depiction of the service line/metering configurations that typically exist in water utilities. This worksheet gives guidance on the determination of the Average Length, Lp, for each configuration.
Average operating pressure Find	This is the average pressure in the distribution system that is the subject of the water audit. Many water utilities have a calibrated hydraulic model of their water distribution system. For these utilities, the hydraulic model can be utilized to obtain a very accurate quantity of average pressure. In the absence of a hydraulic model, the average pressure may be approximated by obtaining readings of static water pressure from a representative sample of fire hydrants or other system access points evenly located across the system. A weighted average of the pressure can be assembled; but be sure to take into account the elevation of the fire hydrants, which typically exist several feet higher than the level of buried water pipelines. If the water utility is compiling the water audit for the first time, the average pressure can be approximated, but with a low data grading. In subsequent years of auditing, effort should be made to improve the accuracy of the average pressure quantity. This will then qualify the value for a higher data grading.
Billed Authorized Consumption	All consumption that is billed and authorized by the utility. This may include both metered and unmetered consumption. See "Authorized Consumption" for more information.
Billed metered consumption Find	All metered consumption which is billed to retail customers, including all groups of customers such as domestic, commercial, industrial or institutional. **It does NOT include water supplied to neighboring utilities (water exported) which is metered and billed. Be sure to subtract any consumption for exported water sales that may be included in these billing roles. Water supplied as exports to neighboring water utilities should be included only in the Water Exported component.** The metered consumption data can be taken directly from billing records for the water audit period. The accuracy of yearly metered consumption data can be refined by including an adjustment to account for customer meter reading lag time since not all customer meters are read on the same day of the meter reading period. However additional analysis is necessary to determine the lag time adjustment value, which may or may not be significant.
Billed unmetered consumption Find	All billed consumption which is calculated based on estimates or norms from water usage sites that have been determined by utility policy to be left unmetered. This is typically a very small component in systems that maintain a policy to meter their customer population. However, this quantity can be the key consumption component in utilities that have not adopted a universal metering policy. **This component should NOT include any water that is supplied to neighboring utilities (water exported) which is unmetered but billed. Water supplied as exports to neighboring water utilities should be included only in the Water Exported component.**

Item Name	Description
Customer metering inaccuracies Find	Apparent water losses caused by the collective under-registration of customer water meters. Many customer water meters gradually wear as large cumulative volumes of water are passed through them over time. This causes the meters to under-register the flow of water. This occurrence is common with smaller residential meters of sizes 5/8-inch and 3/4 inch after they have registered very large cumulative volumes of water, which generally occurs only after periods of years. For meters sized 1-inch and larger - typical of multi-unit residential, commercial and industrial accounts - meter under-registration can occur from wear or from the improper application of the meter; i.e. installing the wrong type of meter or the wrong size of meter, for the flow pattern (profile) of the consumer. For instance, many larger meters have reduced accuracy at low flows. If an oversized meter is installed, most of the time the routine flow will occur in the low flow range of the meter, and a significant portion of it may not be registered. It is important to properly select and install all meters, but particularly large customer meters, size 1-inch and larger. The auditor has two options for entering data for this component of the audit. The auditor can enter a percentage under-registration (typically an estimated value), this will apply the selected percentage to the two categories of metered consumption to determine the volume of water not recorded due to customer meter inaccuracy. Note that this percentage is a composite average inaccuracy for all customer meters in the entire meter population. The percentage will be multiplied by the sum of the volumes in the Billed Metered and Unbilled Metered components. Alternatively, if the auditor has substantial data from meter testing activities, he or she can calculate their own loss volumes, and this volume may be entered directly. Note that a value of zero will be accepted but an alert will appear asking if the customer population is unmetered. Since all metered systems have some degree of inaccuracy, a positive value should be entered. A value of zero in this component is valid only if the water utility does not meter its customer population.
Customer retail unit cost Find	The Customer Retail Unit Cost represents the charge that customers pay for water service. This unit cost is applied routinely to the components of Apparent Loss, since these losses represent water reaching customers but not (fully) paid for. Since most water utilities have a rate structure that includes a variety of different costs based upon class of customer, a weighted average of individual costs and number of customer accounts in each class can be calculated to determine a single composite cost that should be entered into this cell. Finally, the weighted average cost should also include additional charges for sewer, storm water or biosolids processing, but only if these charges are based upon the volume of potable water consumed. For water utilities in regions with limited water resources and a questionable ability to meet the drinking water demands in the future, the Customer Retail Unit Cost might also be applied to value the Real Losses; instead of applying the Variable Production Cost to Real Losses. In this way, it is assumed that every unit volume of leakage reduced by leakage management activities will be sold to a customer. Note: the Free Water Audit Software allows the user to select the units that are charged to customers (either $/1,000 gallons, $/hundred cubic feet, or $/1,000 litres) and automatically converts these units to the units that appear in the "WATER SUPPLIED" box. The monetary units are United States dollars, $.
Infrastructure Leakage Index (ILI) Find	The ratio of the Current Annual Real Losses (Real Losses) to the Unavoidable Annual Real Losses (UARL). The ILI is a highly effective performance indicator for comparing (benchmarking) the performance of utilities in operational management of real losses.
Length of mains Find	Length of all pipelines (except service connections) in the system starting from the point of system input metering (for example at the outlet of the treatment plant). It is also recommended to include in this measure the total length of fire hydrant lead pipe. Hydrant lead pipe is the pipe branching from the water main to the fire hydrant. Fire hydrant leads are typically of a sufficiently large size that is more representative of a pipeline than a service connection. The average length of hydrant leads across the entire system can be assumed if not known, and multiplied by the number of fire hydrants in the system, which can also be assumed if not known. This value can then be added to the total pipeline length. Total length of mains can therefore be calculated as: Length of Mains, miles = (total pipeline length, miles) + [{(average fire hydrant lead length, ft) x (number of fire hydrants)} / 5,280 ft/mile] or Length of Mains, kilometres = (total pipeline length, kilometres) + [{(average fire hydrant lead length, metres) x (number of fire hydrants)} / 1,000 metres/kilometre]
NON-REVENUE WATER Find	= Apparent Losses + Real Losses + Unbilled Metered Consumption + Unbilled Unmetered Consumption. This is water which does not provide revenue potential to the utility.
Number of active AND inactive service connections Find	Number of customer service connections, extending from the water main to supply water to a customer. Please note that this includes the actual number of distinct piping connections, including fire connections, whether active or inactive. This may differ substantially from the number of customers (or number of accounts). **Note: this number does not include the pipeline leads to fire hydrants - the total length of piping supplying fire hyrants should be included in the "Length of mains" parameter.**
Real Losses Find	Physical water losses from the pressurized system (water mains and customer service connections) and the utility's storage tanks, up to the point of customer consumption. In metered systems this is the customer meter, in unmetered situations this is the first point of consumption (stop tap/tap) within the property. The annual volume lost through all types of leaks, breaks and overflows depends on frequencies, flow rates, and average duration of individual leaks, breaks and overflows.
Revenue Water	Those components of System Input Volume that are billed and have the potential to produce revenue.
Service Connection Density Find	=number of customer service connections / length of mains

Item Name	Description
Systematic data handling errors Find	Apparent losses caused by accounting omissions, errant computer programming, gaps in policy, procedure, and permitting/activation of new accounts; and any type of data lapse that results in under-stated customer water consumption in summary billing reports. **Systematic Data Handling Errors result in a direct loss of revenue potential. Water utilities can find "lost" revenue by keying on this component.** Utilities typically measure water consumption registered by water meters at customer premises. The meter should be read routinely (ex: monthly) and the data transferred to the Customer Billing System, which generates and sends a bill to the customer. Data Transfer Errors result in the consumption value being less than the actual consumption, creating an apparent loss. Such error might occur from illegible and mis-recorded hand-written readings compiled by meter readers, inputting an incorrect meter register unit conversion factor in the automatic meter reading equipment, or a variety of similar errors. Apparent losses also occur from Data Analysis Errors in the archival and data reporting processes of the Customer Billing System. Inaccurate estimates used for accounts that fail to produce a meter reading are a common source of error. Billing adjustments may award customers a rightful monetary credit, but do so by creating a negative value of consumption, thus under-stating the actual consumption. Account activation lapses may allow new buildings to use water for months without meter readings and billing. Poor permitting and construction inspection practices can result in a new building lacking a billing account, a water meter and meter reading; i.e., the customer is unknown to the utility's billing system. Close auditing of the permitting, metering, meter reading, billing and reporting processes of the water consumption data trail can uncover data management gaps that create volumes of systematic data handling error. Utilities should routinely analyze customer billing records to detect data anomalies and quantify these losses. For example, a billing account that registers zero consumption for two or more billing cycles should be checked to explain why usage has seemingly halted. Given the revenue loss impacts of these losses, water utilities are well-justified in providing continuous oversight and timely correction of data transfer errors & data handling errors. If the water auditor has not yet gathered detailed data or assessment of systematic data handling error, it is recommended that the auditor apply the default value of 0.25% of the the Billed Authorized Consumption volume. However, if the auditor has investigated the billing system and its controls, and has well validated data that indicates the volume from systematic data handling error is substantially higher or lower than that generated by the default value, then the auditor should enter a quantity that was derived from the utility investigations and select an appropriate grading. Note: negative values are not allowed for this audit component. If the auditor enters zero for this component then a grading of 1 will be automatically assigned.
Total annual cost of operating the water system Find	These costs include those for operations, maintenance and any annually incurred costs for long-term upkeep of the drinking water supply and distribution system. It should include the costs of day-to-day upkeep and long-term financing such as repayment of capital bonds for infrastructure expansion or improvement. Typical costs include employee salaries and benefits, materials, equipment, insurance, fees, administrative costs and all other costs that exist to sustain the drinking water supply. Depending upon water utility accounting procedures or regulatory agency requirements, it may be appropriate to include depreciation in the total of this cost. This cost should not include any costs to operate wastewater, biosolids or other systems outside of drinking water.
Unauthorized consumption Find	Includes water illegally withdrawn from fire hydrants, illegal connections, bypasses to customer consumption meters, or tampering with metering or meter reading equipment; as well as any other ways to receive water while thwarting the water utility's ability to collect revenue for the water. Unauthorized consumption results in uncaptured revenue and creates an error that understates customer consumption. In most water utilities this volume is low and, if the water auditor has not yet gathered detailed data for these loss occurrences, it is recommended that the auditor apply a default value of 0.25% of the volume of water supplied. However, if the auditor has investigated unauthorized occurrences, and has well validated data that indicates the volume from unauthorized consumption is substantially higher or lower than that generated by the default value, then the auditor should enter a quantity that was derived from the utility investigations. Note that a value of zero will not be accepted since all water utilities have some volume of unauthorized consumption occurring in their system. Note: if the auditor selects the default value for unauthorized consumption, a data grading of 5 is automatically assigned, but not displayed on the Reporting Worksheet.
Unavoidable Annual Real Losses (UARL) Find	UARL (gallons/day)=(5.41Lm + 0.15Nc + 7.5Lc) xP, or UARL (litres/day)=(18.0Lm + 0.8Nc + 25.0Lc) xP where: Lm = length of mains (miles or kilometres) Nc = number of customer service connections Lp = the average distance of customer service connection piping (feet or metres) (see the Worksheet "Service Connection Diagram" for guidance on deterring the value of Lp) Lc = total length of customer service connection piping (miles or km) Lc = Nc X Lp (miles or kilometres) P = Pressure (psi or metres) The UARL is a theoretical reference value representing the technical low limit of leakage that could be achieved if all of today's best technology could be successfully applied. It is a key variable in the calculation of the Infrastructure Leakage Index (ILI). Striving to reduce system leakage to a level close to the UARL is usually not needed unless the water supply is unusually expensive, scarce or both. NOTE: The UARL calculation has not yet been proven as fully valid for very small, or low pressure water distribution systems. If, in gallons per day: (Lm x 32) + Nc < 3000 or P <35psi in litres per day: (Lm x 20) + Nc < 3000 or P < 25m then the calculated UARL value may not be valid. The software does not display a value of UARL or ILI if either of these conditions is true.

Item Name	Description
Unbilled Authorized Consumption	All consumption that is unbilled, but still authorized by the utility. This includes Unbilled Metered Consumption + Unbilled Unmetered Consumption. See "Authorized Consumption" for more information. For Unbilled Unmetered Consumption, the Free Water Audit Software provides the auditor the option to select a default value if they have not audited unmetered activities in detail. The default calculates a volume that is 1.25% of the Water Supplied volume. If the auditor has carefully audited the various unbilled, unmetered, authorized uses of water, and has established reliable estimates of this collective volume, then he or she may enter the volume directly for this component, and not use the default value.
Unbilled metered consumption Find	Metered consumption which is authorized by the water utility, but, for any reason, is deemed by utility policy to be unbilled. This might for example include metered water consumed by the utility itself in treatment or distribution operations, or metered water provided to civic institutions free of charge. **It does not include water supplied to neighboring utilities (water exported) which may be metered but not billed.**
Unbilled unmetered consumption Find	Any kind of Authorized Consumption which is neither billed or metered. This component typically includes water used in activities such as fire fighting, flushing of water mains and sewers, street cleaning, fire flow tests conducted by the water utility, etc. In most water utilities it is a small component which is very often substantially overestimated. **It does NOT include water supplied to neighboring utilities (water exported) which is unmetered and unbilled – an unlikely case.** This component has many sub-components of water use which are often tedious to identify and quantify. Because of this, and the fact that it is usually a small portion of the water supplied, it is recommended that the auditor apply the default value, which is 1.25% of the Water Supplied volume. Select the default percentage to enter this value. If the water utility has carefully audited the unbilled, unmetered activities occurring in the system, and has well validated data that gives a value substantially higher or lower than the default volume, then the auditor should enter their own volume. However the default approach is recommended for most water utilities. Note that a value of zero is not permitted, since all water utilities have some volume of water in this component occurring in their system.
Units and Conversions	The user may develop an audit based on one of three unit selections: 1) Million Gallons (US) 2) Megalitres (Thousand Cubic Metres) 3) Acre-feet Once this selection has been made in the instructions sheet, all calculations are made on the basis of the chosen units. Should the user wish to make additional conversions, a unit converter is provided below (use drop down menus to select units from the yellow unit boxes): Enter Units: 1 — Convert From… Million Gallons (US) = **Converts to…..** 3.06888329 Acre-feet (conversion factor = 3.06888328973723)
Use of Option Buttons	To use the default percent value choose this button To enter a value choose this button and enter the value in the cell to the right  **NOTE:** For Unbilled Unmetered Consumption, Unauthorized Consumption and Systematic Data Handling Errors, a recommended default value can be applied by selecting the Percent option. The default values are based on fixed percentages of Water Supplied or Billed Authorized Consumption and are recommended for use in this audit unless the auditor has well validated data for their system. Default values are shown by purple cells, as shown in the example above. If a default value is selected, the user does not need to grade the item; a grading value of 5 is automatically applied (however, this grade will not be displayed).
Variable production cost (applied to Real Losses) Find	The cost to produce and supply the next unit of water (e.g., $/million gallons). This cost is determined by calculating the summed unit costs for ground and surface water treatment and all power used for pumping from the source to the customer. It may also include other miscellaneous unit costs that apply to the production of drinking water. It should also include the unit cost of bulk water purchased as an import if applicable. It is common to apply this unit cost to the volume of Real Losses. However, if water resources are strained and the ability to meet future drinking water demands is in question, then the water auditor can be justified in applying the Customer Retail Rate to the Real Loss volume, rather than applying the Variable Production Cost. The Free Water Audit Software applies the Variable Production costs to Real Losses by default. However, the auditor has the option on the Reporting Worksheet to select the Customer Retail Cost as the basis for the Real Loss cost evaluation if the auditor determines that this is warranted.
Volume from own sources Find	The volume of water withdrawn (abstracted) from water resources (rivers, lakes, streams, wells, etc) controlled by the water utility, and then treated for potable water distribution. Most water audits are compiled for utility retail water distribution systems, so this volume should reflect the amount of treated drinking water that entered the distribution system. Often the volume of water measured at the effluent of the treatment works is slightly less than the volume measured at the raw water source, since some of the water is used in the treatment process. Thus, it is useful if flows are metered at the effluent of the treatment works. If metering exists only at the raw water source, an adjustment for water used in the treatment process should be included to account for water consumed in treatment operations such as filter backwashing, basin flushing and cleaning, etc. If the audit is conducted for a wholesale water agency that sells untreated water, then this quantity reflects the measure of the raw water, typically metered at the source.

Item Name	Description
Volume from own sources: Master meter and supply error adjustment Find	An estimate or measure of the degree of inaccuracy that exists in the master (production) meters measuring the annual Volume from own Sources, and any error in the data trail that exists to collect, store and report the summary production data. This adjustment is a weighted average number that represents the collective error for all master meters for all days of the audit year and any errors identified in the data trail. Meter error can occur in different ways. A meter or meters may be inaccurate by under-registering flow (did not capture all the flow), or by over-registering flow (overstated the actual flow). Data error can occur due to data gaps caused by temporary outages of the meter or related instrumentation. All water utilities encounter some degree of inaccuracy in master meters and data errors in archival systems are common; thus a value of zero should not be entered. Enter a negative percentage or value for metered data under-registration; or, enter a positive percentage or value for metered data over-registration.
Water exported Find	The Water Exported volume is the bulk water conveyed and sold by the water utility to neighboring water systems that exists outside of their service area. Typically this water is metered at the custody transfer point of interconnection between the two water utilities. Usually the meter(s) are owned by the water utility that is selling the water: i.e. the exporter. If the water utility who is compiling the annual water audit sells bulk water in this manner, they are an exporter of water. Note: The Water Exported volume is sold to wholesale customers who are typically charged a wholesale rate that is different than retail rates charged to the retail customers existing within the service area. Many state regulatory agencies require that the Water Exported volume be reported to them as a quantity separate and distinct from the retail customer billed consumption. For these reasons - and others - the Water Exported volume is always quantified separately from Billed Authorized Consumption in the standard water audit. **Be certain not to "double-count" this quantity by including it in both the Water Exported box and the Billed Metered Consumption box of the water audit Reporting Worksheet. This volume should be included only in the Water Exported box.**
Water exported: Master meter and supply error adjustment Find	An estimate or measure of the volume in which the Water Exported volume is incorrect. This adjustment is a weighted average that represents the collective error for all of the metered and archived exported flow for all days of the audit year. Meter error can occur in different ways. A meter may be inaccurate by under-registering flow (did not capture all the flow), or by over-registering flow (overstated the actual flow). Error in the metered, archived data can also occur due to data gaps caused by temporary outages of the meter or related instrumentation. All water utilities encounter some degree of error in their metered data, particularly if meters are aged and infrequently tested. Occasional errors also occur in the archived data. Thus, a value of zero should not be entered. Enter a negative percentage or value for metered data under-registration; or enter a positive percentage or value for metered data over-registration. If regular meter accuracy testing is conducted on the meter(s) - which is usually conducted by the water utility selling the water - then the results of this testing can be used to help quantify the meter error adjustment. Corrections to data gaps or other errors found in the archived data should also be included as a portion of this meter error adjustment.
Water imported Find	The Water Imported volume is the bulk water purchased to become part of the Water Supplied volume. Typically this is water purchased from a neighboring water utility or regional water authority, and is metered at the custody transfer point of interconnection between the two water utilities. Usually the meter(s) are owned by the water supplier selling the water to the utility conducting the water audit. The water supplier selling the bulk water usually charges the receiving utility based upon a wholesale water rate.
Water imported: Master meter and supply error adjustment Find	An estimate or measure of the volume in which the Water Imported volume is incorrect. This adjustment is a weighted average that represents the collective error for all of the metered and archived imported flow for all days of the audit year. Meter error can occur in different ways. A meter may be inaccurate by under-registering flow (did not capture all the flow), or by over-registering flow (overstated the actual flow). Error in the metered, archived data can also occur due to data gaps caused by temporary outages of the meter or related instrumentation. All water utilities encounter some level of meter inaccuracy, particularly if meters are aged and infrequently tested. Occasional errors also occur in the archived metered data. Thus, a value of zero should not be entered. Enter a negative percentage or value for metered data under-registration; or, enter a positive percentage or value for metered data over-registration. If regular meter accuracy testing is conducted on the meter(s) - which is usually conducted by the water utility selling the water - then the results of this testing can be used to help quantify the meter error adjustment.
WATER LOSSES Find	= apparent losses + real losses Water Losses are the difference between Water Supplied and Authorized Consumption. Water losses can be considered as a total volume for the whole system, or for partial systems such as transmission systems, pressure zones or district metered areas (DMA); if one of these configurations are the basis of the water audit.

APPENDIX C

Helpful Tools & References

C-1: AWWA Meter Testing Standards
C-2: Excerpts from Mass DEP's ASR Instructions Manual
C-3: Leak Calculator
C-4: Suggested Recording Table for Distribution System Breaks and Leaks

APPENDIX C-1

AWWA Meter Testing Standards

AWWA Meter Testing Standards

The AWWA M6 manual provides guidance on the testing of meters. For information on meter testing procedures see pages 58-85 of the M6 manual. Regarding the frequency for when each meter should be tested based on size, there is no one standard in the M6 manual. The M6 provides a table, Table 5-2 found on pages 60-61, which shows each State's regulation for the frequency of meter testing as of 1994. In this table, Massachusetts does not have meter testing frequency regulations because as of 1994 no regulations had been adopted. However, based on experience and the table provided in the M6, Weston & Sampson recommends that the following meter testing frequency based on meter size. Each PWS may choose to customize the testing frequency based on actual system parameters and historical testing results.

Meter Size (Inches)	Type	Frequency (Years)
5/8	Positive Displacement	10
3/4	Positive Displacement	8
1	Positive Displacement	6
1 ½	Positive Displacement	4
2	Positive Displacement	4
2	Compound/Turbine/Fire	4
3	Compound/Turbine/Fire	3
4	Compound/Turbine/Fire	2
6	Compound/Turbine/Fire	1
8	Compound/Turbine/Fire	1

APPENDIX C-2

Excerpts from Mass DEP's ASR Instructions Manual

Excerpts from Mass DEP's ASR Instructions Manual

Table DS-4 Confidently Estimated Municipal Use:

Table DS-4 is for reporting unmetered uses of water for municipal purposes. **Losses of water due to ongoing leaks discovered during leak detection surveys are not included.** Water lost to major water main breaks is included, but a description of the break must be provided (location, date, volume of water lost). For all of the water volume reported Table DS-4, provide calculations and documentation of how the volumes were calculated. **Water volumes listed in Table DS-4 will be considered unaccounted for water (UAW) unless documentation is provided.**

Table DS-4 Confidently Estimated Municipal Use volume To qualify as confidently estimated municipal use calculations/documentation for each estimated use must be attached to this ASR or mailed to MassDEP. If no documentation is provided, DEP will count the volumes as unaccounted for water. See ASR Instructions for more detail. Leak detection volumes are not counted as a confidently estimated municipal use. Optional Excel spreadsheets for calculating confidently estimated use can be found at the MADEP website at http://www.mass.gov/dep/water/approvals/dwsforms.htm#statrep

Confidently Estimated Municipal Use (CEMU)		Estimated million gallons per year
Fire protection & training		0.25
Hydrant/water main flushing/main construction	+	4.15
Flow testing	+	0.1
Bleeders/ Blow offs	+	0
Tank overflow & drainage	+	2.5
Sewer & stormwater system flushing	+	0.02
Street cleaning	+	0.05
Source meter calibration adjustments	+	0
Major water main breaks (not leak detection)	+	0.5
Total Confidently Estimated Municipal Use	=	7.57

ReCalculate Total

YOU MUST PROVIDE DOCUMENTATION FOR ALL OF YOUR CEMU VOLUMES.

Guidance on documentation of CEMU volumes. Below are descriptions of some of the ways that CEMU volumes can be documented.

Fire Protection and Training: This volume can be taken from data provided by the local Fire Department (Chief or Deputy's office) in writing or the volumes can be obtained from meters on booster pumps.

Hydrant/water main flushing/main construction: Volumes used during annual or biannual flushing of the distribution network can be calculated by using the number of hydrants times average volume flowed times number of times flushed. Some systems track tank levels before, during and after flushing to estimate volumes used. All hydrant and system flow test volume estimates must be presented in table form to be eligible for municipal use. Volumes of water used to fill new or replaced water mains may be calculated and reported in a tabular form, complete with street, project number or other identifying information.

Flow testing: Flow testing volumes can be calculated using completed Insurance Services Organization (ISO) flow sheets that provide hydrant locations, street addresses and flow rates. Multiply the flow rate for each test times the flushing time, rounded to 5-minute increments. All system flow test volume estimates should be presented in tabular form.

Bleeders / Blow offs: All bleeders should be metered whenever possible. Meter readings should be taken regularly to determine the volumes of water that are run to waste. Metered bleeder volumes should be reported on Table DS-3 under "municipal". For bleeders that cannot be metered, flow rate can measured using a bucket of known volume and a stopwatch and extrapolating an annual volume. Documentation (calculations) must be provided.

Tank overflow & drainage: When a storage tank is overflowed for water quality purposes, the overflow volume can be calculated using daily storage tank readings or flow out of the overflow piping can be calculated using 50% of the flow rate from pumps that are on in the system at the time of the overflow. The duration of the overflow is determined through observation and by when pumps are shut off or when instrumentation controls are adjusted to automatically shut off pumping systems.

Sewer and stormwater system flushing: Water volume used for stormwater flushing or in sewer main work can be confidently estimated through a metered volume using a hydrant meter/construction-type meter.

Street cleaning: Water volume used by street cleaning sweepers can be calculated by multiplying the volume of the street sweeper tank(s) times the number of times filled. Logs should be kept on file.

Source meter calibrations: To account for source meter calibration adjustments, you must provide calibration logs documenting calibration calculation. If you make adjustments to source water volumes, pro-rate adjustments over time. **Example:** Calibration in December 2006 shows that a source meter is under-reading by 12%. It has been 12 months since the last calibration, therefore adjust Jan 2006 upward by 1%, February upward by 2%, etc. Alternatively, taking 50% of the difference between the adjusted and non-adjusted volume results in the same as pro-rating by month as described above.

Major water main breaks: **Leaking water found during leak detection surveys or otherwise discovered is not considered a municipal use and is not included in Table DS-4.** However, very large individual short-term water main breaks can be claimed on a case-by-case basis. Document the date discovered, date repaired, duration of the break, cause (if known) and estimated water loss. MassDEP will review these submittals to determine eligibility.

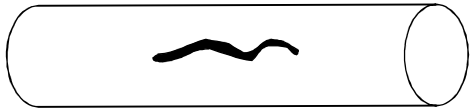
APPENDIX C-3

Leak Calculator

Austin Water Utility Water Loss Calculator*

Rectangular Break

Long Break



Length of break 0 in feet

Width of break 0 in inches

Leak Time 0 in hours

PSI 0

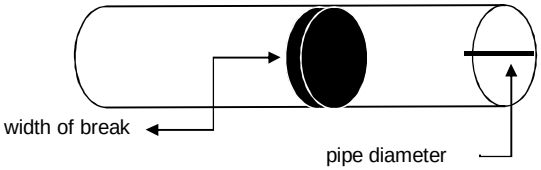
Area of Hole 0 sq. ft.

GPM water loss ⇨ 0

Total Loss ⇨ 0

Circular Break

around whole pipe



Pipe Size (Dia.) in inches

Width of Break in inches

Area of Hole 0 sq. ft.

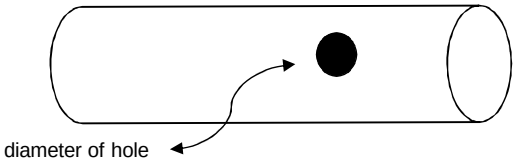
Leak Time in hours

PSI

GPM 0

Total loss 0
in gals

Hole in Pipe



Dia. Of Hole in inches

area of hole 0

Leak Time in hours

PSI

GPM 0

Total Loss 0
in gals

*Source: The Austin Water Utility Water Loss Calculator is available for download online as an excel spreadsheet free of charge.

APPENDIX C-4

Suggested Recording Table for Distribution System Breaks and Leaks

Water Distribution System Failure Log

									Failure Reported		Failure Shut-down		Failure Repaired								
Failure Type (Reported or Unreported)[1]	Address/Location[2]	GPS Coordinates (if cross-country)[2]	Failure Type (main, service, valve, hydrant, meter, tank, etc.)	Description of break (rectangular, circular, hole, etc.)	Diameter of Pipe	Material of Pipe[2]	Install Year[2]	Manufacturer[2]	Date	Time	Date	Time	Date	Time	Est. Flow-Rate	Total Volume Lost	Hours spent on Repair[2]	Suspected Cause of Failure[2]	Soil and Surrounding Conditions[2]	Number of Responders[2]	Equipment On Site for Repair[2]	Additional Comments

Notes: 1) "Unreported" failures are leaks that are identified through active leakage control, typically leak detection surveys. "Reported" failures are all breaks or leaks that are identified visibly by an onlooker, or identified from noticeble changes in water pressure.
2) This information is not explicitly required as data input for the WRF Component Analysis; however, it can be useful for comprehensive asset management in a GIS.