American Water Works Association

Dedicated to the World's Most Important Resource®

CONTROLLING NON-REVENUE WATER IN DRINKING WATER UTILITIES

COURSE 1

ASSESSING NON-REVENUE WATER WITH THE AWWA WATER AUDIT METHOD

ACKNOWLEDGMENTS

Project Contractor

George Kunkel, Kunkel Water Efficiency Consulting

Project Funding

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- George Kunkel, Kunkel Water Efficiency Consulting
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- David Hale, AWWA, Denver, CO
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- Kris Grammerstorf, AWWA, Denver, CO

PURPOSE OF THE COURSE

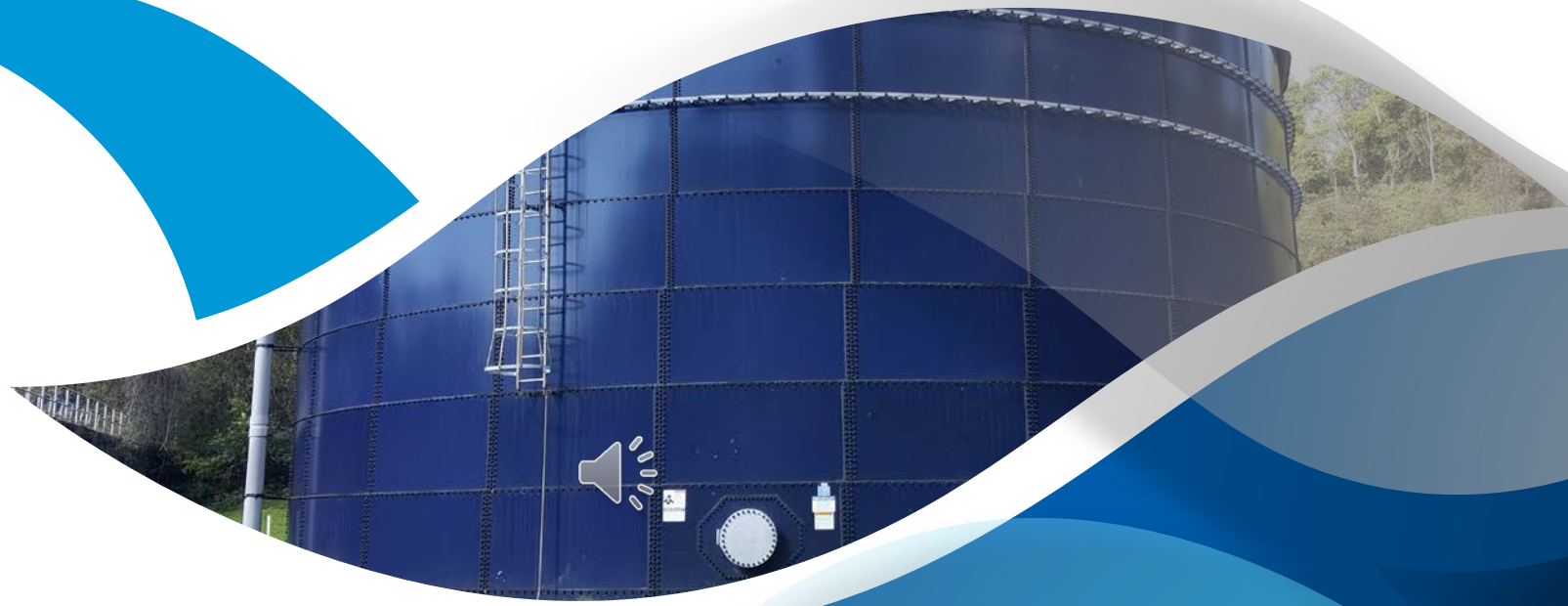
Suggest best practices for establishing key performance indicators and long-term tracking of non-revenue water

Introduce the Water Audit Balance as a tool for quantifying water consumption and loses in a system

Teaching you how to use AWWA's Free Water Audit Software v6

Course Agenda

Module Number	
1	Defining Non-revenue Water (NRW) and Water Audits
2	Using the AWWA Free Water Audit Software v6
3	Using Performance Indicators to Track Progress in Controlling NRW



MODULE 1

Defining NRW and Water Audits

Learning Objectives

1. Interpret the Water Balance diagram and the way it works
2. Recall the definition of NRW and its components
3. Recognize the impacts of NRW on utility operations and customers

Module 1 Agenda

A. The Water Balance

B. Defining Non-revenue Water

C. Unbilled Authorized Consumption

D. Apparent Losses

E. Real (Leakage) Losses

A. The Water Balance

<table>
<tr><td rowspan="11">Volume from Own Sources
(corrected for known errors)</td><td rowspan="12">System Input Volume</td><td rowspan="12">Water Exported
(corrected for known errors)

Water Supplied</td><td colspan="3">Billed Water Exported</td><td>Revenue Water</td></tr>
<tr><td rowspan="2">Authorized Consumption</td><td rowspan="2">Billed Authorized Consumption</td><td>Billed metered consumption</td><td rowspan="2">Revenue Water</td></tr>
<tr><td>Billed unmetered consumption</td></tr>
<tr><td rowspan="8">Water Losses</td><td rowspan="2">Unbilled Authorized Consumption</td><td>Unbilled metered consumption</td><td rowspan="8">Non-revenue Water</td></tr>
<tr><td>Unbilled unmetered consumption</td></tr>
<tr><td rowspan="3">Apparent Losses</td><td>Customer metering inaccuracies</td></tr>
<tr><td>Unauthorized consumption</td></tr>
<tr><td>Systematic data handling error</td></tr>
<tr><td rowspan="3">Real Losses</td><td>Leakage on water mains</td></tr>
<tr><td>Leakage on customer service connections</td></tr>
<tr><td>Storage tank overflows</td></tr>
<tr><td>Water Imported
(corrected for known errors)</td></tr>
</table>

All components are measured as volume of water per year

B. Defining Non-revenue Water

Water produced by a water utility each year (**Water Supplied Volume**)

-

Water consumed by the utility's customers (**Billed Authorized Consumption**)

=

Non-revenue Water

Defining Non-revenue Water

Leakage

Unauthorized Consumption

Meter error

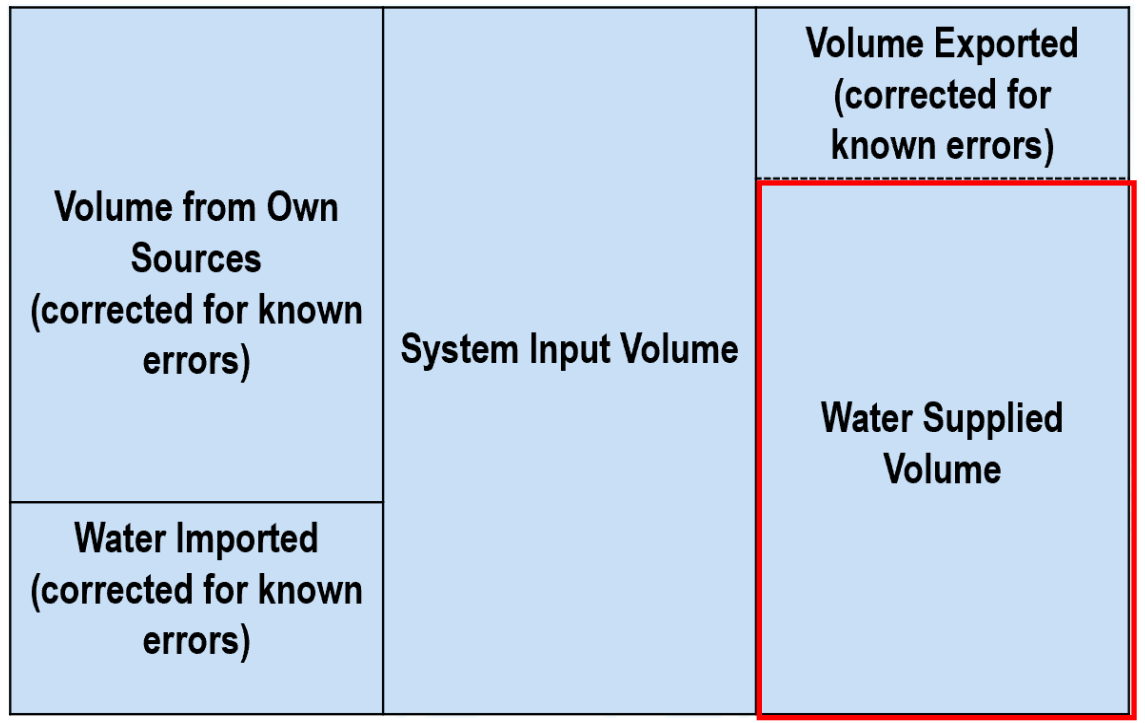
Water used in fire hydrant flushing

Wait! Is the last one actually a loss?

B. Defining Non-revenue Water:

Calculating the Water Supplied Volume

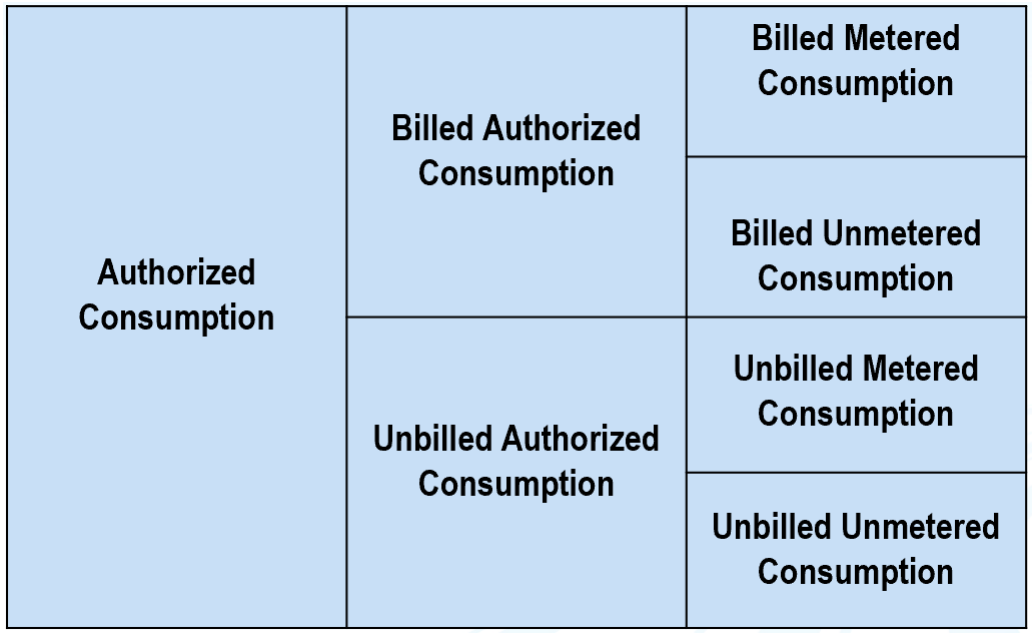
1. Sum the annual **Volume from Own Sources**: your wells, lakes, rivers, etc.
2. Add **Water Imported** from other suppliers to give the **System Input Volume**
3. Subtract **Water Exported** to other suppliers to give:
4. the ***Water Supplied Volume,*** or the volume of water sent to the retail water distribution system



B. Defining Non-revenue Water:

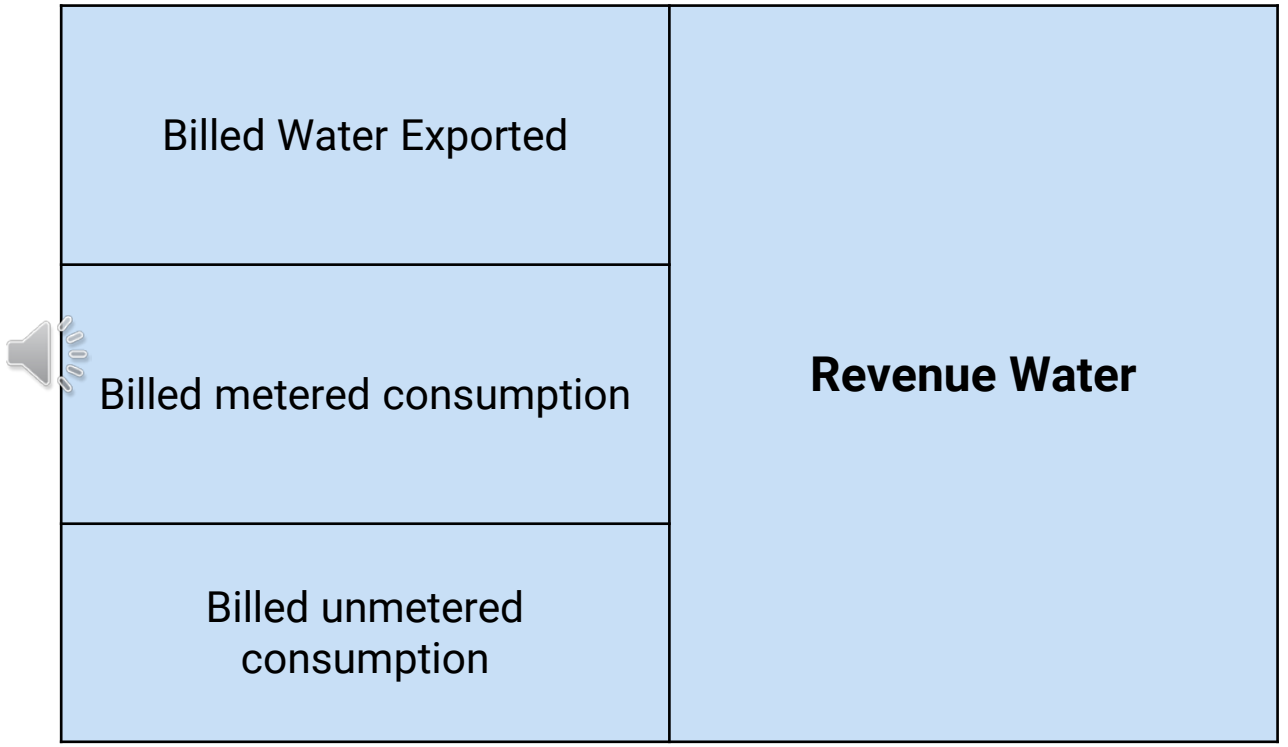
Next: look at Water Consumed

- Water utilities permit customers to consume water that they produce, this is known as ***Authorized Consumption***
- Authorized Consumption can be metered or unmetered, and billed or unbilled
- The water utility's policies determine who is billed, and who is metered



B. Defining Non-revenue Water

- **Revenue Water**: annual water supplied volume that is billed to paying customers, including:
  - Other utilities (water exported)
  - Metered customers
  - Unmetered customers



Ideally, most of the water that you supply becomes Revenue Water!

B. Defining Non-revenue Water (NRW)

- Non-revenue Water is made up of:
  - Unbilled authorized consumption
  - Apparent Losses
  - Real Losses (leakage)
- As defined, revenue is lost

Nonrevenue Water	Unbilled Authorized Consumption	**Unbilled metered consumption**
		Unbilled unmetered consumption
	Apparent Losses	Systematic Data Handling Error
		Customer Metering Inaccuracies
		Unauthorized Consumption
	Real Losses	Leakage on water mains
		Leakage on customer service connections
		Storage tank overflows

B. Defining Non-revenue Water (NRW)

- All utilities have NRW
- NRW can be controlled

The AWWA Water Balance – KNOWLEDGE CHECK

<table>
<tr><td rowspan="10">Volume from Own Sources
(corrected for known errors)</td><td rowspan="11">System Input Volume</td><td rowspan="11">Water Exported
(corrected for known errors)</td><td colspan="3">Billed Water Exported</td><td rowspan="2">Revenue Water</td></tr>
<tr><td rowspan="2">Authorized Consumption</td><td rowspan="2">Billed Authorized Consumption</td><td>Billed metered consumption</td></tr>
<tr><td>Billed unmetered consumption</td><td rowspan="2">Revenue Water</td></tr>
<tr><td rowspan="5">Water Losses</td><td rowspan="2">Unbilled Authorized Consumption</td><td>Unbilled metered consumption</td><td rowspan="6"></td></tr>
<tr><td>Unbilled unmetered consumption</td></tr>
<tr><td rowspan="3"></td><td>Customer metering inaccuracies</td></tr>
<tr><td>Unauthorized consumption</td></tr>
<tr><td>Systematic data handling error</td></tr>
<tr><td rowspan="4">Real Losses</td><td>Leakage on water mains</td></tr>
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<tr><td>Storage tank overflows</td></tr>
<tr><td>Water Imported
(corrected for known errors)</td></tr>
</table>

Three of the boxes on this Water Balance diagram are missing the name of the component.
Type the name of the missing component in each of these three boxes shown by the white line

True or False

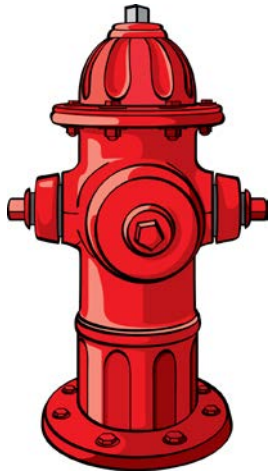
- Some utilities have no losses, meaning their Non-revenue Water is zero
  - True
  - False

True or False

- **Some utilities have no losses, meaning their Non-revenue Water is zero**
  - **True** 
  - **False** 

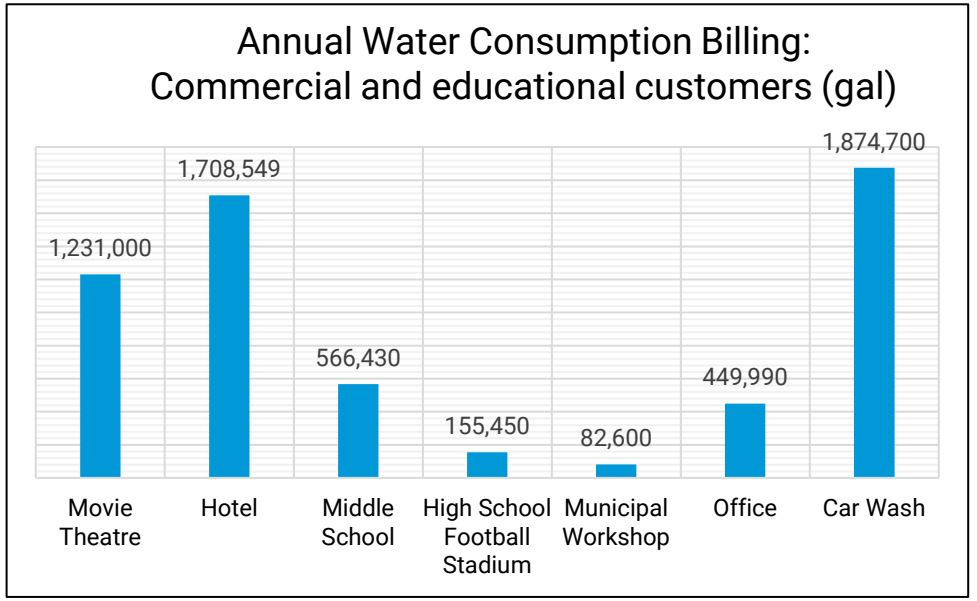
C. Unbilled Authorized Consumption

- Unbilled Authorized Consumption *is* part of Non-revenue Water, *but it is not a loss*
- When consumption is unbilled, the utility spends money to treat and deliver water, but gains no revenue in return
- Some Unbilled Authorized Consumption is unavoidable
  - Fire hydrant flushing
  - Fire Department use
- ***But sometimes this consumption is allowed by a discretionary decision by the water utility management……***



D. Apparent Losses

- **Systematic Data Handling Error** – unintentional lapses that result in under-billed customers:
  - Meter reading error and data transfer error
  - Customer accounts erroneously left off the billing roles
  - Billing adjustments that alter consumption values
  - Other types of error



- Water utilities can investigate by:
  - Having summary reports that reveal billing data trends
  - Track average consumption by class of customer each billing cycle
  - Conduct data analysis on the billing system data

D. Defining Apparent Losses – the Individual Components

- **Customer metering inaccuracies**:
  - Mechanical meters that “run slow” under-register water consumption
  - These meters have moving parts that eventually wear and slow down
  - Over-sized water meters
  - Water meter failure

- Water utilities can maintain good meter accuracy by:
  - Periodically testing some meters for accuracy
  - Replacing meters before they wear excessively and lose appreciable accuracy

Typical positive displacement (mechanical) water meter for residential customer applications

D. Defining Apparent Losses – the Individual Components

- **Unauthorized Consumption** – taking water without paying, in ways not permitted by the utility, including:
  - Illegally opening fire hydrants
  - Illegal water line connections
  - Tampering with water meters or meter reading equipment
- Water utilities can control unauthorized consumption by:
  - Having sound policy that defines the uses that are permitted
  - Detecting unauthorized consumption when it occurs
  - Enforcing penalties for infractions

Water meter at top was illegally removed and replaced with a “straight” pipe or “meter jumper”

D. Apparent Loss Impacts

WATER UTILITY IMPACTS

- Lost revenue from customer under-billing
- Damaged fire hydrants and water meters from tampering
- Customer consumption totals are under-stated, affecting:
  - Customer consumption reporting
  - Water conservation tracking
  - Planning studies

CUSTOMER IMPACTS

- Frustration and complaints from billing errors
- Possibly more frequent water rate increases
  - ***When some customers under-pay for water (or don't pay at all), this means other customers bear the weight of funding the water utility***

APPARENT LOSS IMPACTS

WATER UTILITY

- Lost revenue
- Damage from tampering
- Incorrect consumption total

CUSTOMER

- Complaints
- Water rate increases

D. Problems with Apparent Losses – KNOWLEDGE CHECK

Let's check on your impression of apparent loss problems:

On the below list, check the <u>one</u> occurrence that is <u>not</u> a problem caused by apparent losses.

1. The utility billing clerk reported five incidents of malfunctioned or "frozen" meters.
2. The water utility Board of Directors decided to allow the mayor of the town to have water service for free.
3. Testing of five residential customer meters found them to under-register flow by more than 10 percent.
4. Four new homes were built in the town and began using water. The utility billing clerk realized that billing accounts for the homes had not been created and the new homes were not billed during their first 4 months of water usage.
5. An inspection found the town's major industry – a meat packing plant – had an illegal water line tapped into the unmetered fire line supplying their plant.

This graphic assumes that viewers can click on a box built-in to the screen to identify the answer to the question

E. Real (Leakage) Losses

- Real Losses occurs from:
  - Leakage on water mains, customer service connections, and as water escaping from storage tank overflows
- Leakage on piping systems occur from:
  - Corrosion of metallic pipelines
  - Extreme hot or cold temperature stresses
  - Poor installation practices; inferior materials
  - High water pressure or pressure surges
  - Third-party damage by contractors, highway crews, etc.
- Leakage means more water is treated and pumped than the customer population consumes

Storage Tank overflow

Leak detection on plastic pipe

E. Problems with Leakage (Real Losses)

WATER SUPPLY OPERATIONS IMPACTS

- Low pressure in the distribution system
- Water tank levels drop quickly, or tanks are hard to fill
- Increased source water withdrawals
- Increased Pumping and treatment
- Staff time for leak detection and repair work
- Increased risks to drinking water quality

E. Problems with Leakage (Real Losses)

CUSTOMER IMPACTS

- Reduced pressure/water outages
- Flooding damage in below-ground basements
- Street damage/excavations for repairs – roads are restricted or closed
- Poor public relations/poor image for the water utility

INDIRECT IMPACTS

- Leakage entering sewers may be treated twice:
  - At the water treatment plant and the wastewater treatment plant
- Increased liability from damage claims
- Excessive water demands, meaning:
  - Existing pumping and piping capacity may be over-stressed
  - New infrastructure may be oversized – to meet higher demands from leakage

E. Problems with Leakage: KNOWLEDGE CHECK

On the below list, check the one occurrence that is not a likely problem that can be caused by leakage:

This graphic assumes that viewers can click on a box built-in to the screen to identify the answer to the question

1. Treated drinking water begins pooling in basements of customer properties
2. Treated drinking water bubbling from a street freezes during cold weather and spreads ice on the roadway
3. Water pressure in a section of the distribution system suddenly drops so low it causes customer complaints
4. A water utility flushes fire hydrants in a way that creates “rusty water” complaints
5. Water spraying from a worn pipe joint undermines the street bedding, creating a sinkhole in a road

Some typical losses that occur in water utilities

remember this question from earlier?

Leakage

Unauthorized Consumption

Meter error

Water used in fire hydrant flushing

Is water flushed from a fire hydrant a loss?

Water consumed in flushing hydrants is part of unbilled, unmetered consumption. Thus, it is not a loss, but it is part of Non-revenue Water.

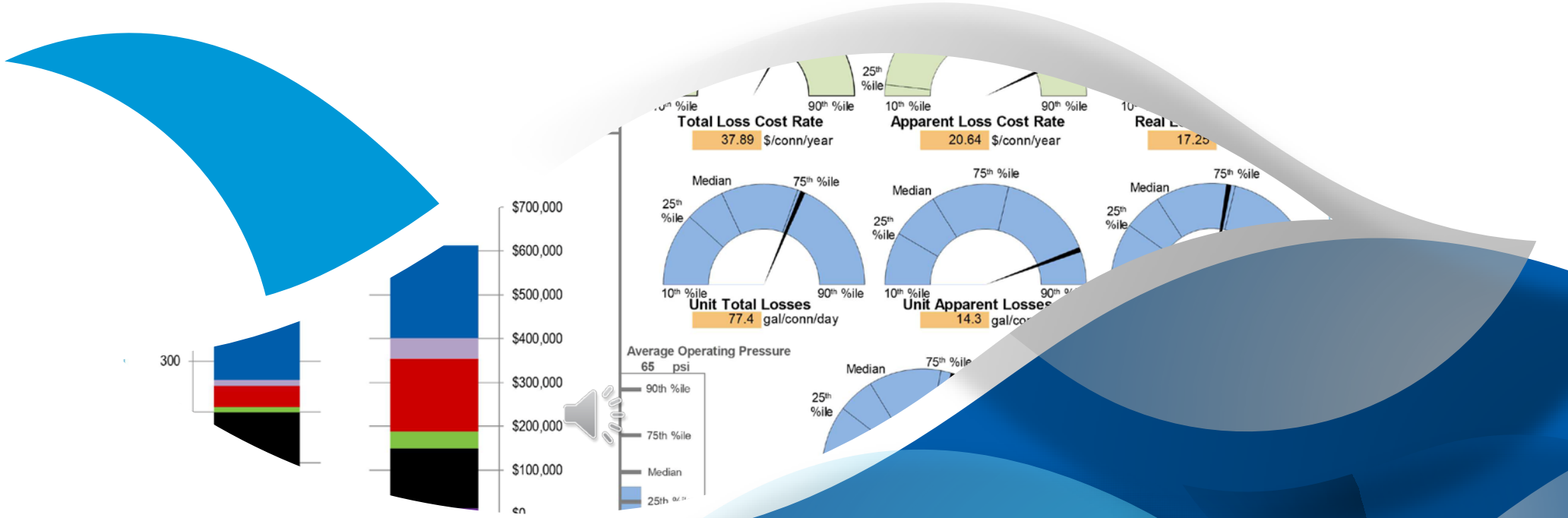
Module 1 Summary:

Non-revenue water is the water a utility produces that does not capture revenue

All water utilities have non-revenue water to some degree

Non-revenue water consists of:

- Unbilled authorized consumption
- Apparent losses
- Real losses – distribution system leakage and storage tank overflows



MODULE 2

Using the AWWA Free Water Audit Software v6

Module 2 Agenda

Getting and Using the AWWA Free Water Audit Software

Using the AWWA Free Water Audit Software

Interactive Data Grading Feature

The Compiler Software

Learning Objectives

As a result of this Module participants will be able to:

1. Navigate AWWA's Free Water Audit Software v6
2. Gather their key data and input it into the Software
3. Assess operational practices by answering questions in the Interactive Data Grading feature
4. Obtain and use the Compiler Software

A. Getting and Using the AWWA Free Water Audit Software

What is a *water audit?*

"An examination of water production, customer billing, and cost records to check their accuracy and measure water efficiency"

A. The AWWA Water Audit Method

RECOMMENDATIONS FOR WATER AUDITS

- The water audit covers a 12-month period that follows the utility's financial year, calendar year, or yearly period as defined by a regulatory agency.
- A water audit cannot be compiled on less than a 12-month basis.
- However, many water utilities conduct monthly NRW tracking, and this can be done on a general basis, but only if:
  - An approximation of NRW is calculated as the difference between the water supplied volumes and billed authorized consumption volumes ***on a rolling 12-month basis***
  - It is inaccurate to calculate the above difference using data from a single month

A. The AWWA Water Audit Method

12-month Period	Water Supplied Volume, mg	Billed Authorized Consumption, mg	Non-revenue Water Volume, mg	Number of Commercial, Industrial Customer Accounts	Number of Residential Customer Accounts	Total Customer Accounts
February 2018 - January 2019	44.536	30.006	14.530	23	588	611
March 2018 - February 2019	45.237	30.567	14.670	23	586	609
April 2018 - March 2019	43.877	29.873	14.004	23	586	609
May 2018 - April 2019	43.623	29.685	13.937	24	586	610
June 2018 - May 2019	44.007	30.123	13.884	24	585	609
July 2018 - June 2019	44.889	30.621	14.268	24	584	608
August 2018 - July 2019	45.234	30.448	14.786	24	584	608
September 2018 - August 2019	45.668	30.727	14.941	23	584	607
October 2018 - September 2019	44.932	30.602	14.330	23	584	607
November 2018 - October 2019	44.213	30.112	14.101	22	585	607
December 2018 - November 2019	44.458	30.085	14.373	22	585	607
January 2019 - December 2019	44.389	29.832	14.557	22	584	606

Rolling 12-month Average Data shown in a Standard Monthly Report
Number of accounts is tallied on the final day of each month

A. The AWWA Water Audit Method

Key data and typical utility data sources

Data	Information Source
Production flows, pressures	Supervisory Control and Data Acquisition (SCADA) system, or production meter reading log sheets
Customer meter data	Meter Management System or Customer Information System, or meter maintenance cards with repair or accuracy test information
Customer billing data	Customer Billing Software System or Customer Information System, or billing logs/spreadsheets
System maintenance data	Computerized Maintenance Management System and/or Geographic Information System, or maintenance logs
Capital Program data	Infrastructure replacement project lists, or Capital Program Tracking System

A. The AWWA Water Audit Method

Data tracking: collect & review the below seven monthly volumes each month; this will make end-of-year auditing go smoothly

Monthly Tracking

Volume from Own Sources*

Water Imported*

Water Exported*

Billed Metered Consumption

Billed Unmetered Consumption

Unbilled Metered Consumption

Unbilled Unmetered Consumption

*+/- Master Meter & Supply Error Adjustment

Annual Tracking

Customer Meter Inaccuracy

Unauthorized Consumption

Systematic Data Handling Errors

Length of Mains

Number of Connections

Customer Retail Rate

Variable Production Cost

Annual Operating Cost (*optional*)

KNOWLEDGE CHECK

The AWWA Water Audit Method is based on a period of how many months?

1 month

3 months

12 months

KNOWLEDGE CHECK

The AWWA Water Audit Method is based on a period of how many months?

1 month

3 months

12 months

A. Obtaining the AWWA Free Water Audit Software

The Software exists in Microsoft Excel software, so you'll need this software on your personal computer

Download the Water Audit Software at the AWWA website's Resource page at:

https://www.awwa.org/Resources-Tools/Resource-Topics/Water-Loss-Control/Free-Water-Audit-Software

Provide your contact information as shown at the right and click "Submit"

There is no charge to obtain the Water Audit Software and you don't need to be an AWWA member to receive it

AWWA's Free Water Audit Software v6

Free Water Audit Software

The new Free Water Audit Software (v6.0) is now available!

Check out the following items to learn more about it:

- AWWA Water Software v6.0 Release Memo
- Watch the AWWA Water Audit Software v6.0 Orientation Video

Other supporting resources for v6.0 include:

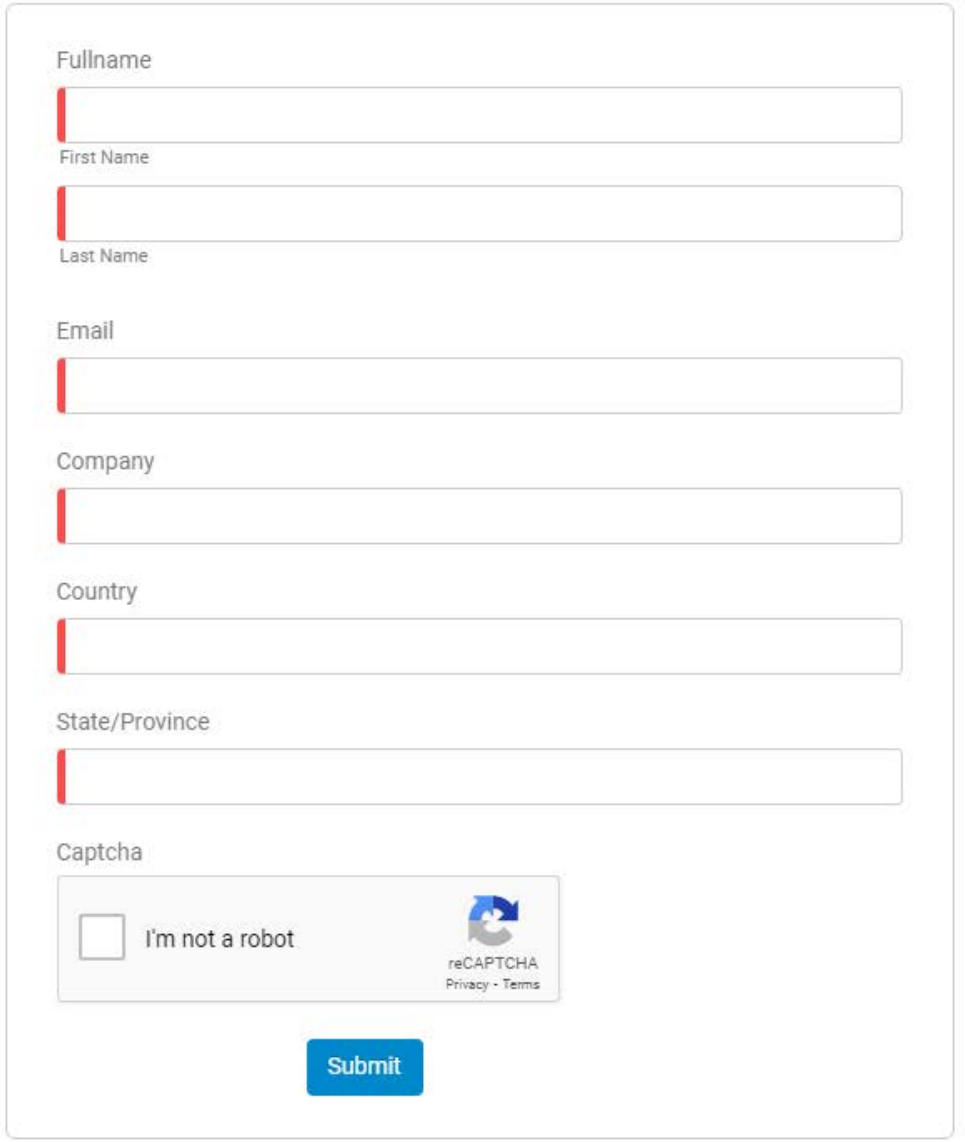
- Example Water Audit v6.0
- Data Grading Matrix v6.0
- Watch the new AWWA Water Audit Software webinar to learn about key upgrades included in version 6.0.

Fill out the short form to download the **AWWA Free Water Audit Software v6.0** (2020).

Version 5.0 (2014) is also available in English and French by completing this form (version Francaise - MAMH du Quebec). AWWA recommends using v6.0 unless your regulatory agency requires you to use v5.0. Version 6.0 will be available in French in mid to late-2021.

Your information will not be shared with third parties.

Contact AWWA with any questions.

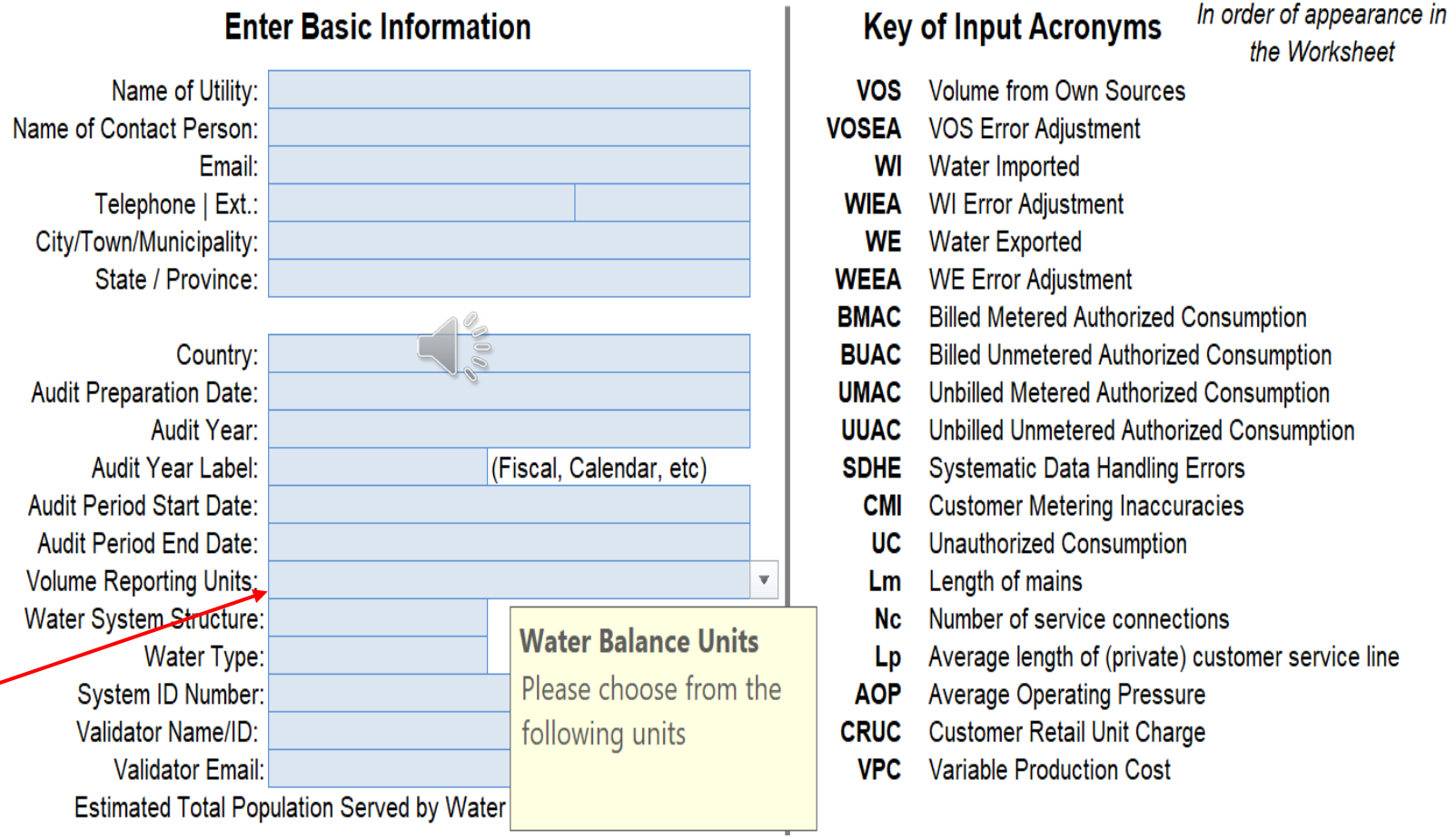


https://www.awwa.org/Resources-Tools/Resource-Topics/Water-Loss-Control/Free-Water-Audit-Software

B. Using the AWWA Free Water Audit Software

START PAGE

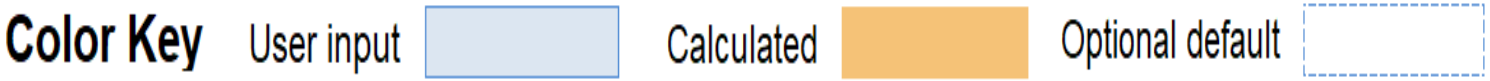
- This is the first worksheet in the Software
- Enter information on the water utility on this worksheet
- **Important**: enter the Volume Reporting Units: the options are million gallons, metric units of mega-litres (thousand cubic meters), and Acre-feet
- A listing of Acronyms is also provided



AWWA Free Water Audit Software – Start Page Worksheet

B. Using the AWWA Free Water Audit Software

START PAGE WORKSHEET – Color coding and default values



Guidance for the Worksheet

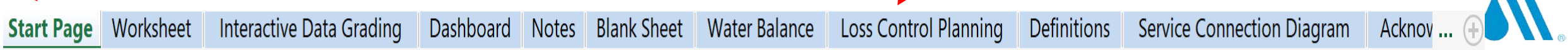
Choosing to enter unit of **percent** or **volume**
(applies to VOSEA, WIEA, WEEA, CMI)
choose entry option:

1.00%	percent	*or*
	volume	25.000

Choosing to enter **default** or **custom input**
(applies to UUAC, SDHE, UC)
choose entry option:

0.25%	default	*or*
	custom	75.000

Tabs at the bottom of each worksheet allow you to navigate to other worksheets



Data cells are color coded to designate how the data is handled

- Blue cells – enter your data in these cells; data are numbers, or sometimes percentages (as accuracy)
- Orange cells – these are values calculated by the Software based upon your data inputs. You don't enter data here.
- White cells – indicate that a ***default****, or suggested minimal value, can be used if you don't have a reasonable value to input, with cells available to enter either a customer value or to select the default

Note: only three inputs have the option to use a default value

B. Using the AWWA Free Water Audit Software – KNOWLEDGE CHECK

START PAGE WORKSHEET

On the Start Page Worksheet excerpt to the right, identify where to enter the below information by selecting the cell – coded by a letter – in the dark blue box next to the entry:

1. *Name of the City/Utility* **Community Water Authority** — 1.__
2. *The year:* **2020 (click the dropdown box to the right of Year to select type)** — 2.__
3. *Volume reporting units:* **million gallons** — 3.__

Enter Basic Information

Name of Utility:	A	
Name of Contact Person:	B	
Email:	C	
Telephone | Ext.:	D	
City/Town/Municipality:	E	
State / Province:	F	
Country:	G	
Audit Preparation Date:	H	
Audit Year:	I	
Audit Year Label:	J	(Fiscal, Calendar, etc)
Audit Period Start Date:	K	
Audit Period End Date:	L	
Volume Reporting Units:	M	
Water System Structure:	N	
Water Type:	O	
System ID Number:	P	
Validator Name/ID:	Q	
Validator Email:	R	
Estimated Total Population Served by Water Utility:	S	

Excerpt of the Start Page Worksheet

B. Using the AWWA Free Water Audit Software – KNOWLEDGE CHECK

START PAGE WORKSHEET

The correct data input locations are shown in the slide to the right, highlighted in red:

1. *Name of the City/Utility as* **Community Water Authority** — 1. A
2. *The year:* **2020** — 2. I
3. *Volume reporting units:* **million gallons** — 3. M

Enter Basic Information

Name of Utility:	Community Water Authority
Name of Contact Person:	
Email:	
Telephone | Ext.:	
City/Town/Municipality:	
State / Province:	
Country:	
Audit Preparation Date:	
Audit Year:	2020
Audit Year Label:	(Fiscal, Calendar, etc)
Audit Period Start Date:	
Audit Period End Date:	
Volume Reporting Units:	Million gallons (US)
Water System Structure:	
Water Type:	
System ID Number:	
Validator Name/ID:	
Validator Email:	
Estimated Total Population Served by Water Utility:	

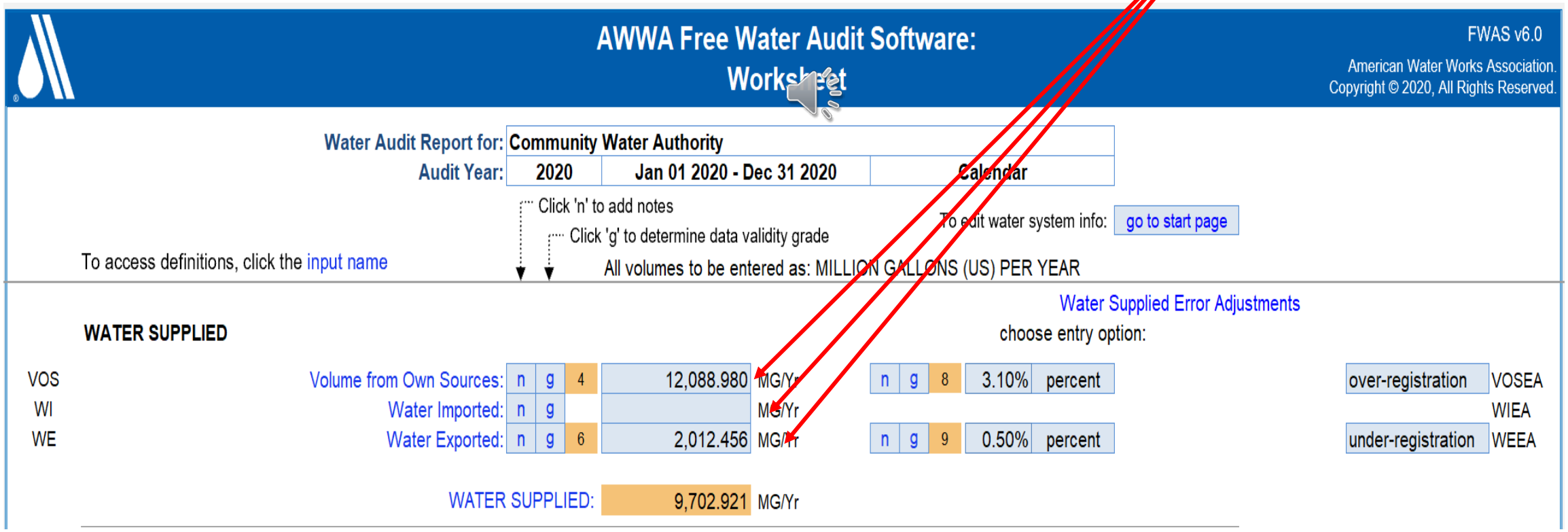
Excerpt of the Start Page Worksheet

Course 1 Module 2

B. Using the AWWA Free Water Audit Software

WATER SUPPLIED VOLUMES

Enter the annual Volume from Own Water Sources, and Imported/Exported volumes (if they exist) here



AWWA Free Water Audit Software: Worksheet

FWAS v6.0

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Water Audit Report for: Community Water Authority

Audit Year: 2020 | Jan 01 2020 - Dec 31 2020 | Calendar

Click 'n' to add notes

Click 'g' to determine data validity grade

To edit water system info: go to start page

To access definitions, click the input name

All volumes to be entered as: MILLION GALLONS (US) PER YEAR

WATER SUPPLIED

Water Supplied Error Adjustments

choose entry option:

VOS	Volume from Own Sources:	n	g	4	12,088.980	MG/Yr	n	g	8	3.10%	percent	over-registration	VOSEA
WI	Water Imported:	n	g			MG/Yr							WIEA
WE	Water Exported:	n	g	6	2,012.456	MG/Yr	n	g	9	0.50%	percent	under-registration	WEEA

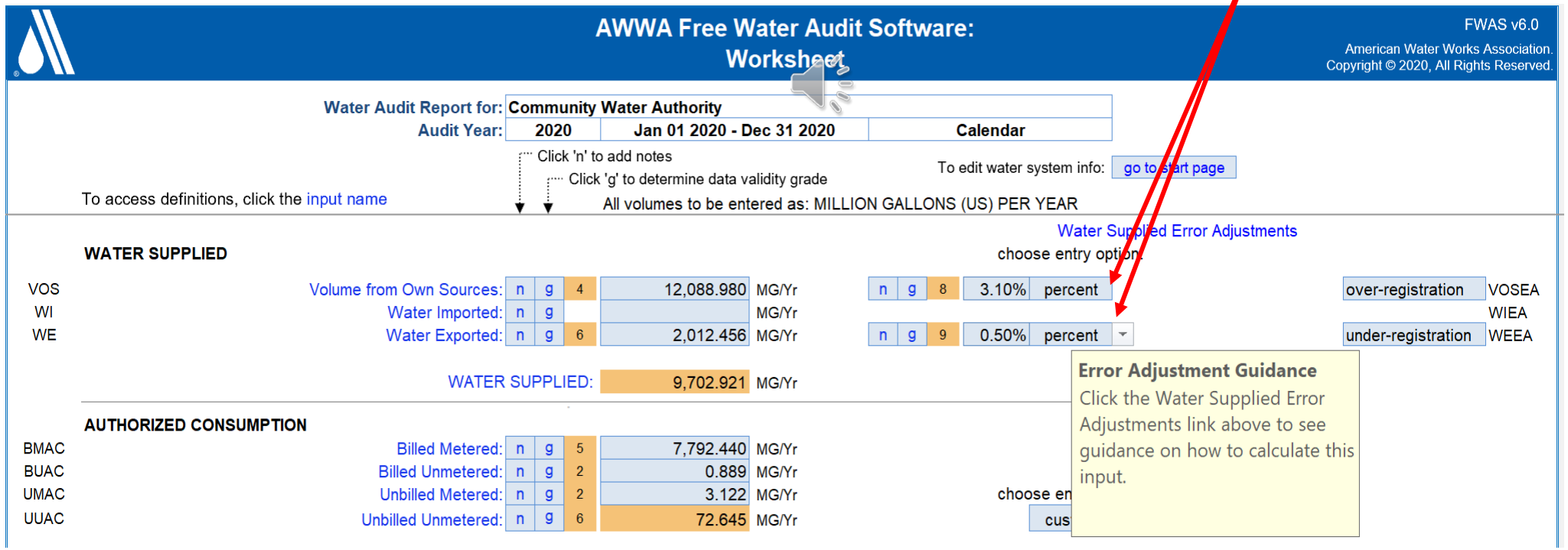
WATER SUPPLIED: 9,702.921 MG/Yr

Water Supplied Excerpt of the “Worksheet”

B. Using the AWWA Free Water Audit Software

REPORTING WORKSHEET – WATER SUPPLIED ERROR ADJUSTMENTS

Enter the estimated degree of error in the volume quantities, in either a percentage or volume of water by selecting from the drop-down menu to the right of each cell



Water Supplied Excerpt of the “Worksheet”

B. Using the AWWA Free Water Audit Software

CALCULATING FLOWMETER ACCURACY

Flowmeter accuracy calculation and example

$$\text{Accuracy (\%)} = \frac{\text{meter indicated flow rate}}{\text{actual flow rate}} \times 100$$

Example: A flow of 100 gpm results in 1000 gallons measured over 10 minutes, but the flowmeter only registered 969.1 gallons. What is the flowmeter accuracy, expressed as a percentage?

$$\text{Accuracy (\%)} = \frac{969.1}{1{,}000} \times 100 = 96.91\%, \text{ or } 3.09\% \text{ inaccuracy}$$

Since the flowmeter produced a number that is *less* than the actual flow, it ***under-registers***.
In the Software, select the percentage option from the drop-down menu and enter *3.09* in the percent error. Then, in the blue cell to the far right, select *under-registration* option.

B. Using the AWWA Free Water Audit Software

KNOWLEDGE CHECK – FLOWMETER ACCURACY

A pumped flow rate of 1,250 gpm resulted in 50,000 gallons over 40 minutes, but the flowmeter registered 52,840 gallons. What is the accuracy of the flowmeter, expressed as a percentage? (select the correct answers from the menu)

1. Use the below equation to calculate the flowmeter accuracy and the answer:

$$Accuracy\ (\%) = \frac{meter\ indicated\ flow\ rate}{actual\ flow\ rate}\ x\ 100$$

A. 102.84%
B. 94.62%
C. 105.7%

2. Calculate the percent inaccuracy of the flowmeter = 100% - flowmeter% = ____

A. +5.70%
B. -5.38%
C. +2.84%

3. Is this under-registration or over-registration? _____

B. Using the AWWA Free Water Audit Software

KNOWLEDGE CHECK – FLOWMETER ACCURACY – ANSWER KEY

A pumped flow rate of 1,250 gpm resulted in 50,000 gallons over 40 minutes, but the flowmeter registered 52,840 gallons. What is the accuracy of the flowmeter, expressed as a percentage? (select the correct answers from the menu)

1. Use the below equation to calculate the flowmeter accuracy and the answer:

$$Accuracy\ (\%) = \frac{meter\ indicated\ flow\ rate}{actual\ flow\ rate} \times 100$$

A. 102.84%
B. 94.62%
C. 105.7%

2. Calculate the percent inaccuracy of the flowmeter = 100% - flowmeter% = ____

A. +5.70%
B. -5.38%
C. +2.84%

3. Is this under-registration or over-registration? **Over-registration**

Course 1 Module 2

B. Using the AWWA Free Water Audit Software

WORKSHEET – SUMMARIZING THE WATER SUPPLIED SECTION

Volume from own Sources +/- Volume from own Sources Master Meter & Supply Error Adjustment

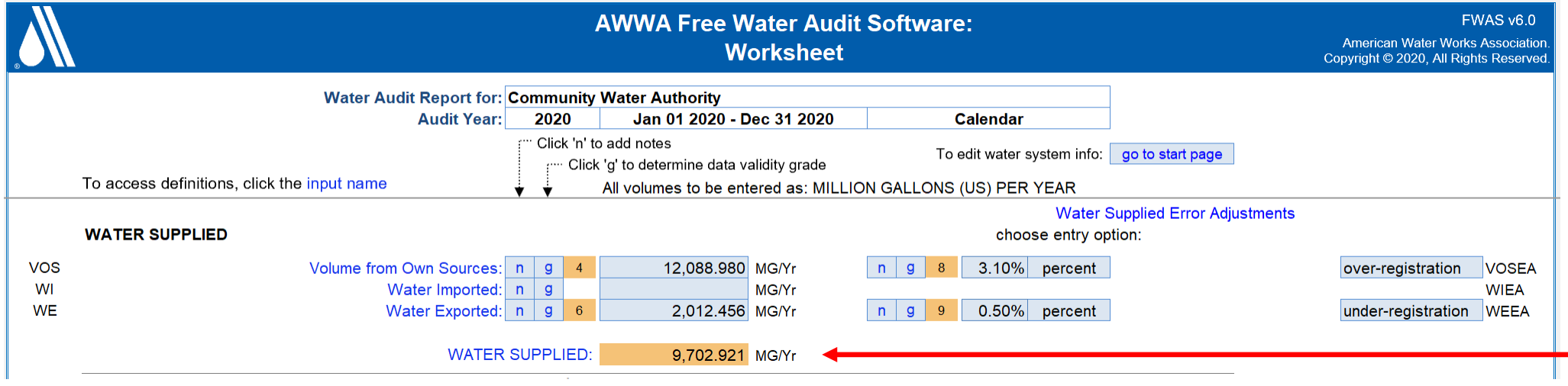
plus

Water Imported +/- Water Imported Master Meter & Supply Error Adjustment

minus

Water Exported +/- Water Exported Master Meter & Supply Error Adjustment

equals **Water Supplied Volume**



AWWA Free Water Audit Software: Worksheet

FWAS v6.0

Water Audit Report for: Community Water Authority

Audit Year: 2020 | Jan 01 2020 - Dec 31 2020 | Calendar

Click 'n' to add notes

Click 'g' to determine data validity grade

To edit water system info: go to start page

To access definitions, click the input name

All volumes to be entered as: MILLION GALLONS (US) PER YEAR

WATER SUPPLIED

Water Supplied Error Adjustments

choose entry option:

VOS	Volume from Own Sources:	n	g	4	12,088.980	MG/Yr	n	g	8	3.10% percent	over-registration	VOSEA
WI	Water Imported:	n	g			MG/Yr						WIEA
WE	Water Exported:	n	g	6	2,012.456	MG/Yr	n	g	9	0.50% percent	under-registration	WEEA
	WATER SUPPLIED:				9,702.921	MG/Yr						

B. Using the AWWA Free Water Audit Software

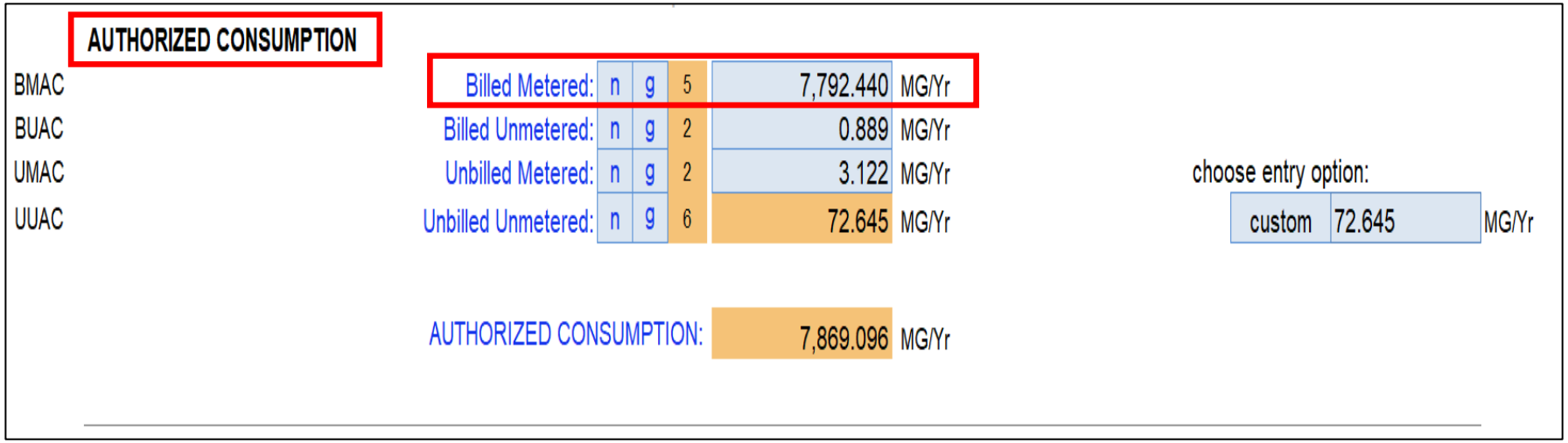
WORKSHEET - AUTHORIZED CONSUMPTION SECTION

Authorized Consumption is broken down into four sub-components, based upon whether it is:

"Billed" or "Unbilled" as well as "Metered" or "Unmetered"

Billed Metered Consumption:

- Potable water usage* by customers in buildings; tracked in a customer billing account
- Utilities often distinguish between residential and non-residential (commercial/industrial) accounts
- Utilities usually read the customer meter every 30, 60, or 90 days to determine water usage
- Bills are sent to customers based (in part) on their consumption volume for the billing period



*should not include recycled or reuse water that is billed to customers, if it exists

B. Using the AWWA Free Water Audit Software

WORKSHEET - AUTHORIZED CONSUMPTION SECTION

Billed Metered Consumption – Data Source

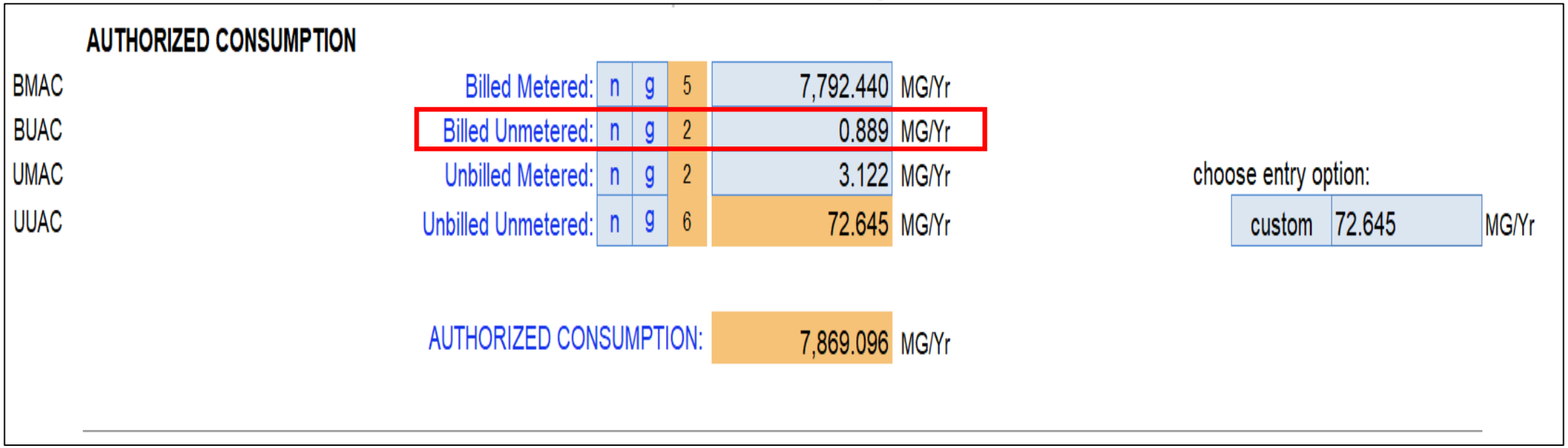
- Meter readings gathered manually, with handheld device, or electronically via AMR or AMI systems
- Meter readings are used to calculate customer consumption as the basis for the variable charge of the water bill
- Fixed charges are also usually included in the bill
- Consumption and charges are stored in a recordkeeping system, such as:
  - Computerized billing system
  - Accounting software packages
  - Spreadsheet software
  - Paper records

B. Using the AWWA Free Water Audit Software

WORKSHEET - AUTHORIZED CONSUMPTION SECTION

Billed Unmetered Consumption:

- Water usage from buildings that is billed to customers but is permitted by utility management to be unmetered
- Since this water usage is unmeasured, it must be estimated for the water audit

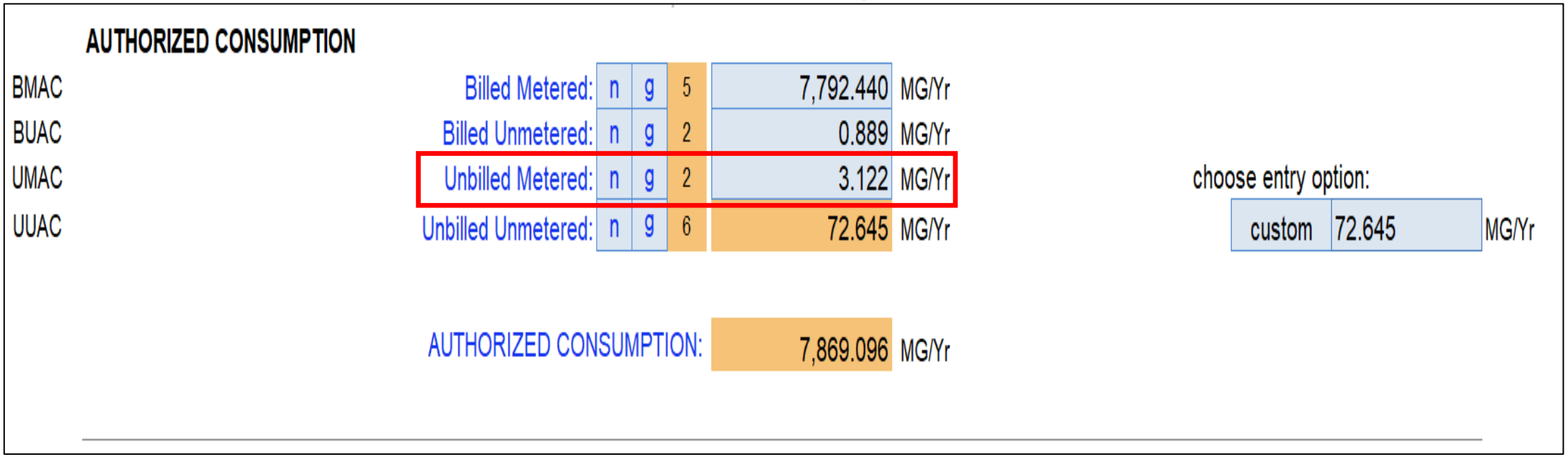


B. Using the AWWA Free Water Audit Software

WORKSHEET - AUTHORIZED CONSUMPTION SECTION

Unbilled Metered Consumption:

- Metered accounts that are unbilled often exist as “free water” or “courtesy” accounts
- It is good practice to meter and bill all customers at least a minimal charge
- It is best to keep the number of Unbilled Metered accounts to a minimum



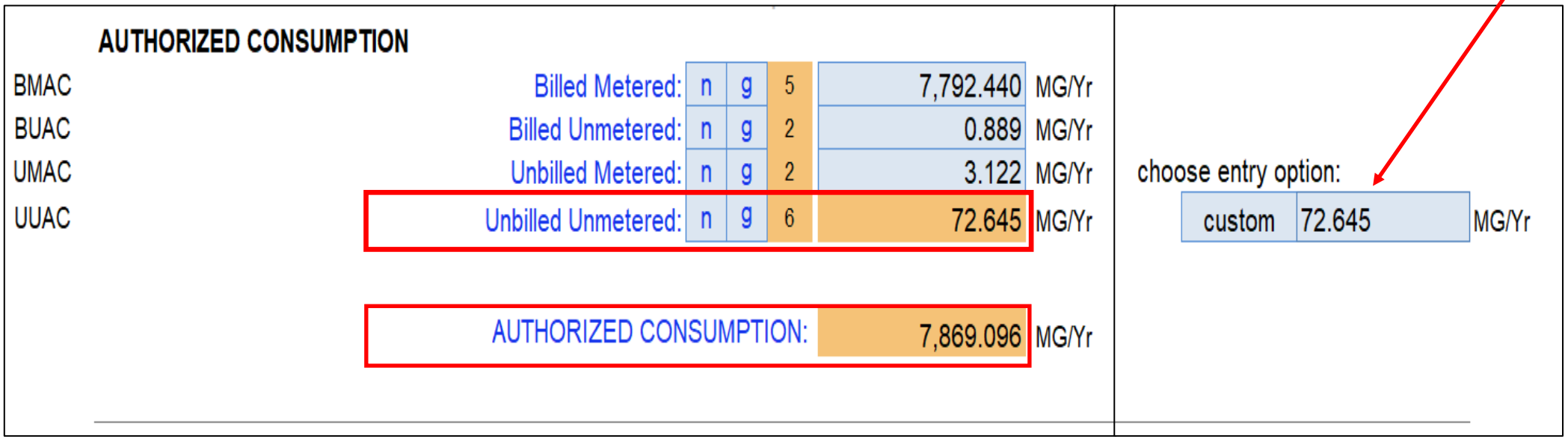
AUTHORIZED CONSUMPTION							
BMAC	Billed Metered:	n	g	5	7,792.440	MG/Yr	
BUAC	Billed Unmetered:	n	g	2	0.889	MG/Yr	
UMAC	Unbilled Metered:	n	g	2	3.122	MG/Yr	choose entry option:
UUAC	Unbilled Unmetered:	n	g	6	72.645	MG/Yr	custom 72.645 MG/Yr
	AUTHORIZED CONSUMPTION:				7,869.096	MG/Yr	

B. Using the AWWA Free Water Audit Software

WORKSHEET - AUTHORIZED CONSUMPTION SECTION

Unbilled Unmetered Consumption:

- Water usage that typically occurs from non-building sources: fire hydrants, flushing ports, etc.
- The user can input in the cells in the right section of the worksheet, either as:
  - A volume calculated by the user (shown here), or
  - By selecting the default value (0.25% of Billed Authorized consumption)

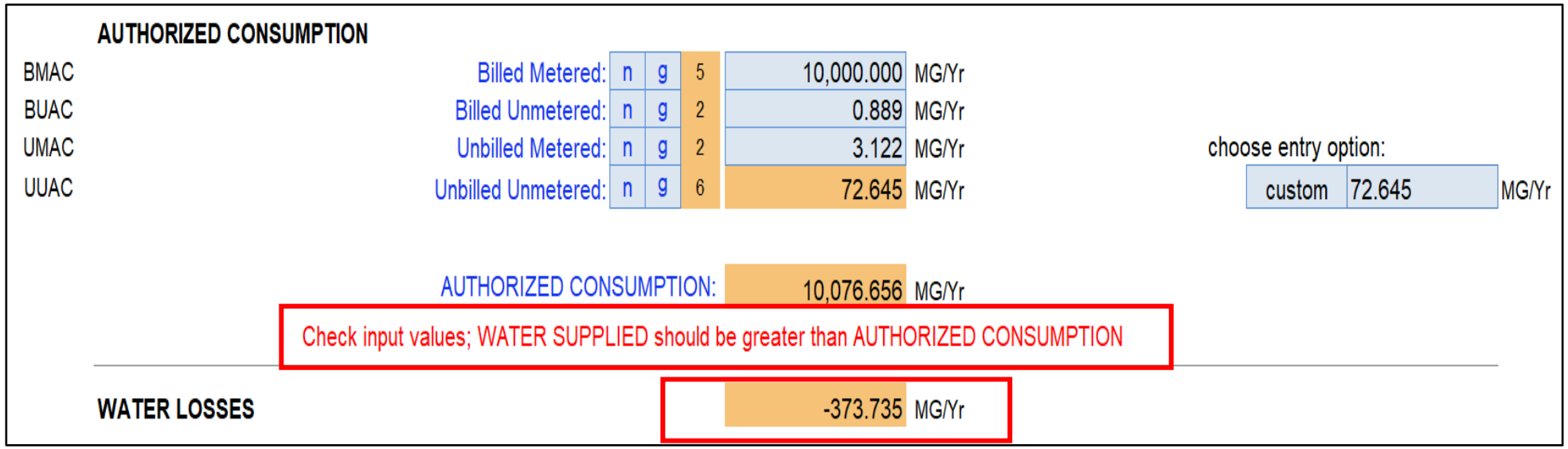


B. Using the AWWA Free Water Audit Software

WORKSHEET - AUTHORIZED CONSUMPTION SECTION

Confirming your primary data inputs:

- The **Water Supplied** and **Authorized Consumption** volumes are now entered
- Confirmation check: *Water Supplied <u>should be greater than</u> Authorized Consumption*
- If this is not the case a cautionary message will be displayed, as shown below
- If this happens, go back and recheck your data inputs for errors

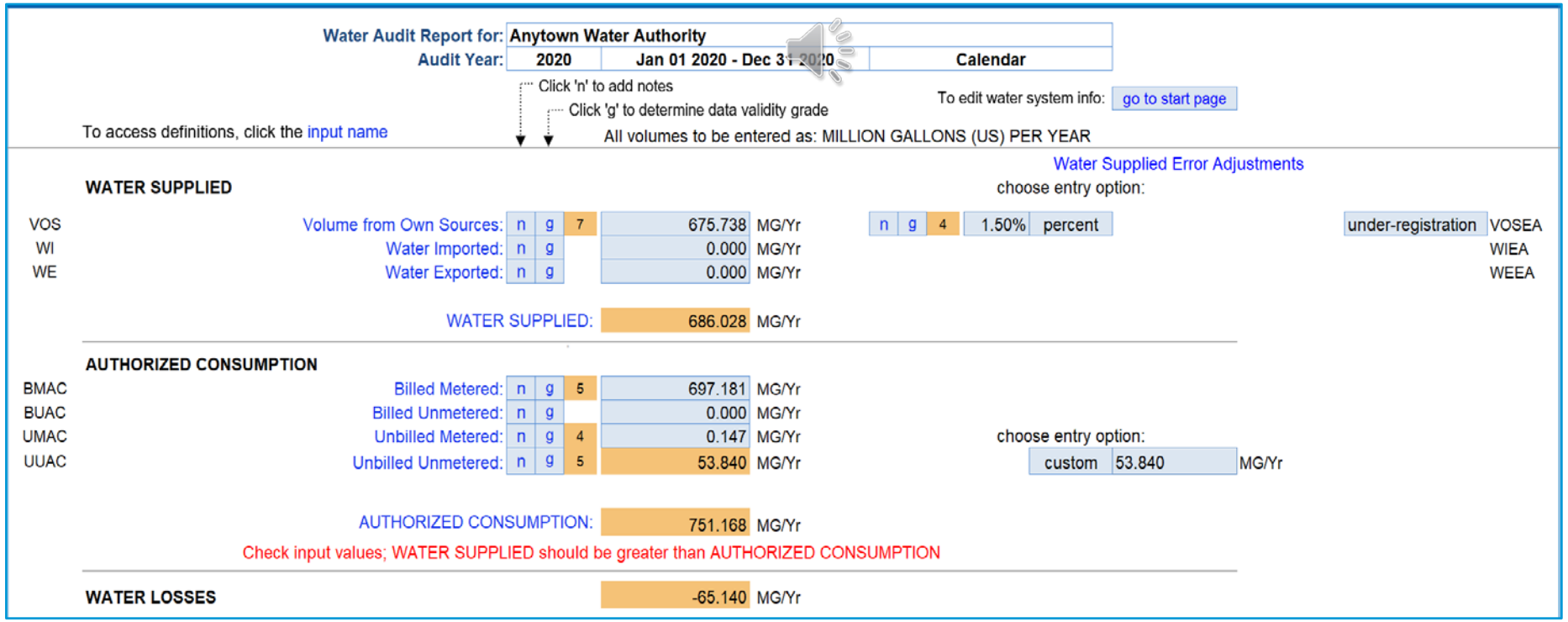


B. Using the AWWA Free Water Audit Software

WORKSHEET - AUTHORIZED CONSUMPTION SECTION - KNOWLEDGE CHECK

The water audit worksheet shown below has flagged a message because the Authorized Consumption volume is greater than the Water Supplied Volume. What could account for this in the water audit (select the best answer from the list)?

A. No leakage exists in the system
B. Unbilled, unmetered consumption is erroneously high
C. Volume from own Sources is erroneously low, or Billed Metered Consumption is erroneously high



Water Audit Report for: Anytown Water Authority
Audit Year: 2020 | Jan 01 2020 - Dec 31 2020 | Calendar

Click 'n' to add notes
Click 'g' to determine data validity grade
To edit water system info: go to start page
To access definitions, click the input name
All volumes to be entered as: MILLION GALLONS (US) PER YEAR

	WATER SUPPLIED					Water Supplied Error Adjustments choose entry option:				
VOS	Volume from Own Sources:	n	g	7	675.738 MG/Yr	n	g	4	1.50% percent	under-registration VOSEA
WI	Water Imported:	n	g		0.000 MG/Yr					WIEA
WE	Water Exported:	n	g		0.000 MG/Yr					WEEA
	WATER SUPPLIED:				686.028 MG/Yr					
	AUTHORIZED CONSUMPTION									
BMAC	Billed Metered:	n	g	5	697.181 MG/Yr					
BUAC	Billed Unmetered:	n	g		0.000 MG/Yr					
UMAC	Unbilled Metered:	n	g	4	0.147 MG/Yr	choose entry option:				
UUAC	Unbilled Unmetered:	n	g	5	53.840 MG/Yr	custom 53.840 MG/Yr				
	AUTHORIZED CONSUMPTION:				751.168 MG/Yr					

Check input values; WATER SUPPLIED should be greater than AUTHORIZED CONSUMPTION

	WATER LOSSES				-65.140 MG/Yr					

B. Using the AWWA Free Water Audit Software

WORKSHEET - AUTHORIZED CONSUMPTION SECTION - KNOWLEDGE CHECK

The water audit worksheet shown below has flagged a message because the Authorized Consumption volume is greater than the Water Supplied Volume. What could account for this in the water audit (select the best answer from the list)?

A. No leakage exists in the system
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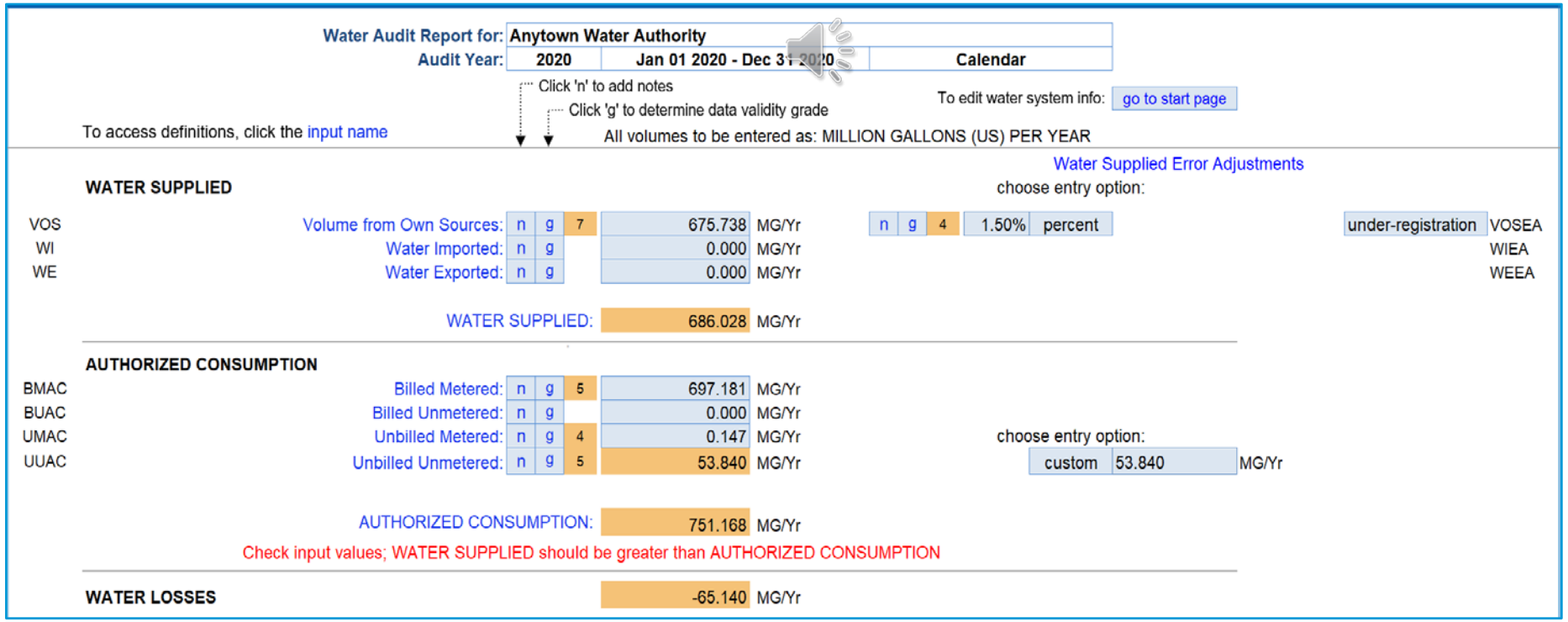
C. Volume from own Sources is erroneously low, or Billed Metered Consumption is erroneously high



Water Audit Report for: Anytown Water Authority
Audit Year: 2020 | Jan 01 2020 - Dec 31 2020 | Calendar

Click 'n' to add notes
Click 'g' to determine data validity grade
To edit water system info: go to start page
To access definitions, click the input name
All volumes to be entered as: MILLION GALLONS (US) PER YEAR

	WATER SUPPLIED					Water Supplied Error Adjustments choose entry option:				
VOS	Volume from Own Sources:	n	g	7	675.738 MG/Yr	n	g	4	1.50% percent	under-registration VOSEA
WI	Water Imported:	n	g		0.000 MG/Yr					WIEA
WE	Water Exported:	n	g		0.000 MG/Yr					WEEA
	WATER SUPPLIED:				686.028 MG/Yr					
	AUTHORIZED CONSUMPTION									
BMAC	Billed Metered:	n	g	5	697.181 MG/Yr					
BUAC	Billed Unmetered:	n	g		0.000 MG/Yr					
UMAC	Unbilled Metered:	n	g	4	0.147 MG/Yr	choose entry option:				
UUAC	Unbilled Unmetered:	n	g	5	53.840 MG/Yr	custom 53.840 MG/Yr				
	AUTHORIZED CONSUMPTION:				751.168 MG/Yr					

Check input values; WATER SUPPLIED should be greater than AUTHORIZED CONSUMPTION

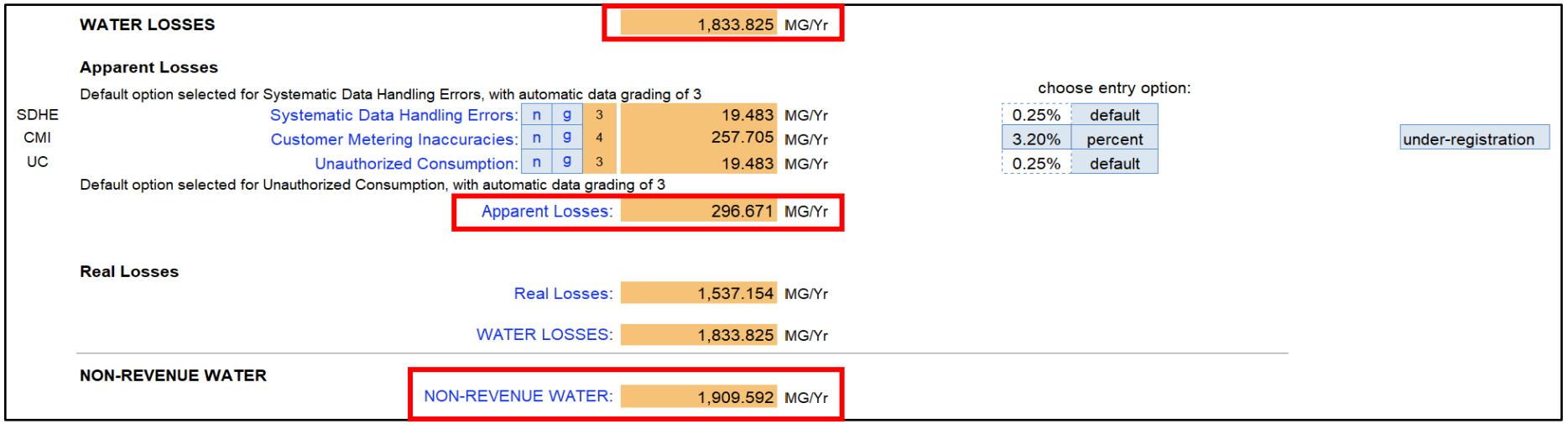
	WATER LOSSES				-65.140 MG/Yr					

B. Using the AWWA Free Water Audit Software

WORKSHEET – LOSSES AND NON-REVENUE WATER SECTION

Calculating Water Losses, Apparent Losses, and Non-revenue Water

- At this stage, the Software calculates **Water Losses,** and the auditor will input **Apparent Losses**
- **Apparent Losses** are the non-physical losses that occur when water reaches a customer but, for various reasons, the utility failed to record and bill some of the consumed water
- Apparent Losses = Systematic Data Handling Error (in customer billing operations) + Customer Metering Inaccuracies + Unauthorized Consumption: each volume will be input by the auditor



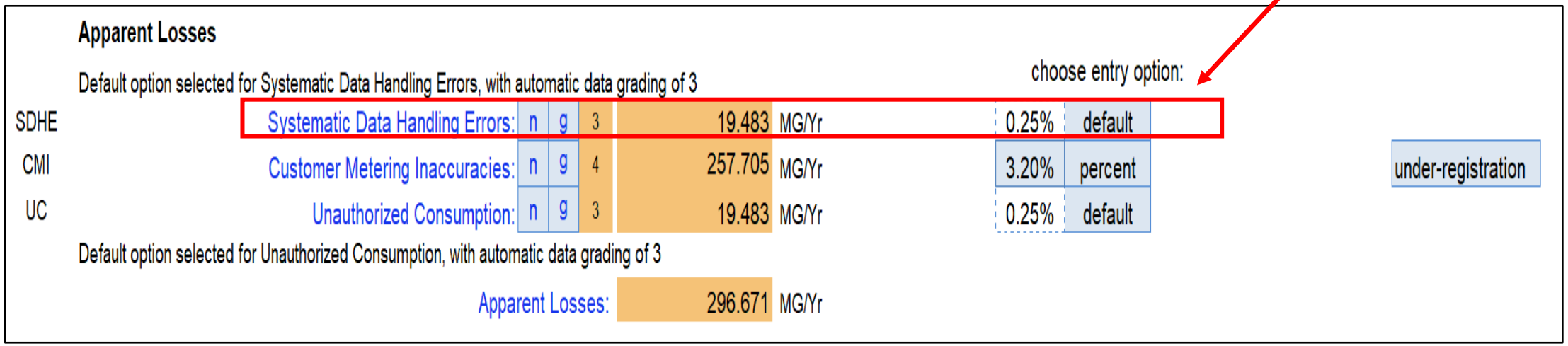
Once apparent losses are input, the Software calculates the **Non-revenue Water** volume

B. Using the AWWA Free Water Audit Software

WORKSHEET – APPARENT LOSSES

- **Systematic Data Handling Error (SDHE):** error in customer consumption data that occurs in billing operations
- In the Software, users can quantify this component by selecting in the blue cells to the right by:
  - inputting a custom volume that the user has calculated

    or
  - a default value of 0.25% of the Billed Authorized Consumption volume



B. Using the AWWA Free Water Audit Software

REPORTING WORKSHEET – APPARENT LOSSES

Systematic Data Handling Error in Customer Billing Operations

Errors that occur in the consumption data once it is obtained from the meter; classified as:

- **Data Transfer Error**: getting the meter reading to the billing system; manually or automatically
- **Data Handling Error**: in the billing process such as poor procedures or programming quirks

Meter register reading is not visible due to moisture under the register enclosure

A handheld meter reading device can reduce the incidence of Data Transfer Error

B. Using the AWWA Free Water Audit Software

WORKSHEET – APPARENT LOSSES

Tracking Systematic Data Handling Error: estimating consumption lost to billing error

- **Example calculation**
  - Two customer accounts were found to be omitted from the billing roles
  - Assume each event ran 10 months
  - Average monthly residential consumption was 4,450 gallons
  - Missing consumption volume =

    (4,450 gallons/customer/month) x 2 customers x 10 months =

    89,000 gal = 0.089 mg

B. Using the AWWA Free Water Audit Software

WORKSHEET – APPARENT LOSSES: CUSTOMER METERING INACCURACIES (CMI)

Older 5/8-inch water meter in an outdoor meter pit

CMI occurs from:

- Improperly installed meters
- Stopped or frozen meter (meter failure)
- Oversized meter relative to the customer flow profile
- Wrong type of meter for the customer flow profile
- Meter defects
- Wear on mechanical meters causing them to run slow

Small meter test bench in use

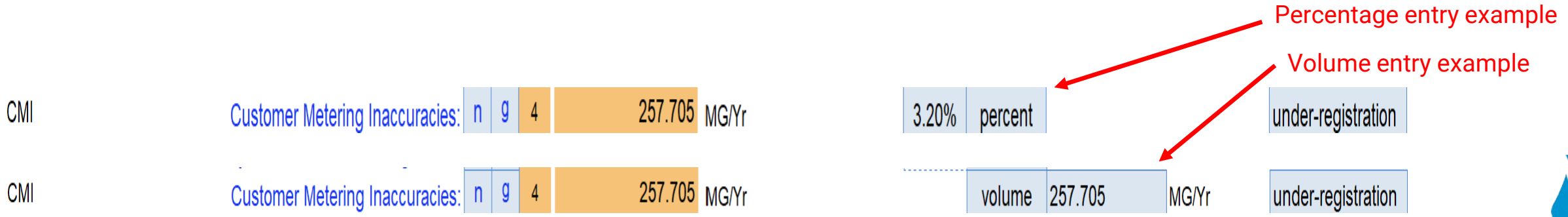
Accuracy Testing

- Water meters can be tested on site ("in-situ") or removed and tested on a test bench
- Testing can be done inhouse or by a testing service

B. Using the AWWA Free Water Audit Software

WORKSHEET – APPARENT LOSSES: CUSTOMER METERING INACCURACIES (CMI)

- Most water utilities do not conduct regular customer meter accuracy testing, so how can CMI be quantified?
- All meters are inaccurate to a certain degree.
- ***Meters performing within plus or minus 2.00% inaccuracy is a taken as a "good" level of performance, if the meters are less than 20 years old.***
  - Assuming inaccuracy under 2% is unrealistic unless the meter is new, or testing confirms it
  - Older, worn meters can incur inaccuracy much more than 2.00%; use good judgement
- The Software allows entry of an aggregate percentage inaccuracy value, or an aggregate inaccuracy volume. The auditor must select one of the two ways to input the value.



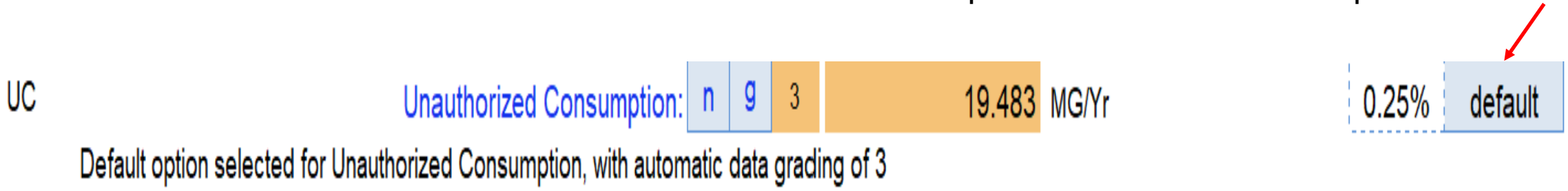
B. Using the AWWA Free Water Audit Software

WORKSHEET – APPARENT LOSSES: UNAUTHORIZED CONSUMPTION (UC)

- **Unauthorized Consumption** is water taken without the consent of, or against the regulations, of the water utility; specifically with the intention of not paying for the water.
- In the Software, users can input this value by selecting from the dropdown menu in the blue cell to the right, a custom volume of loss due to unauthorized consumption:

or

- Select the DEFAULT value of 0.25% of Billed Authorized Consumption Volume from the dropdown menu



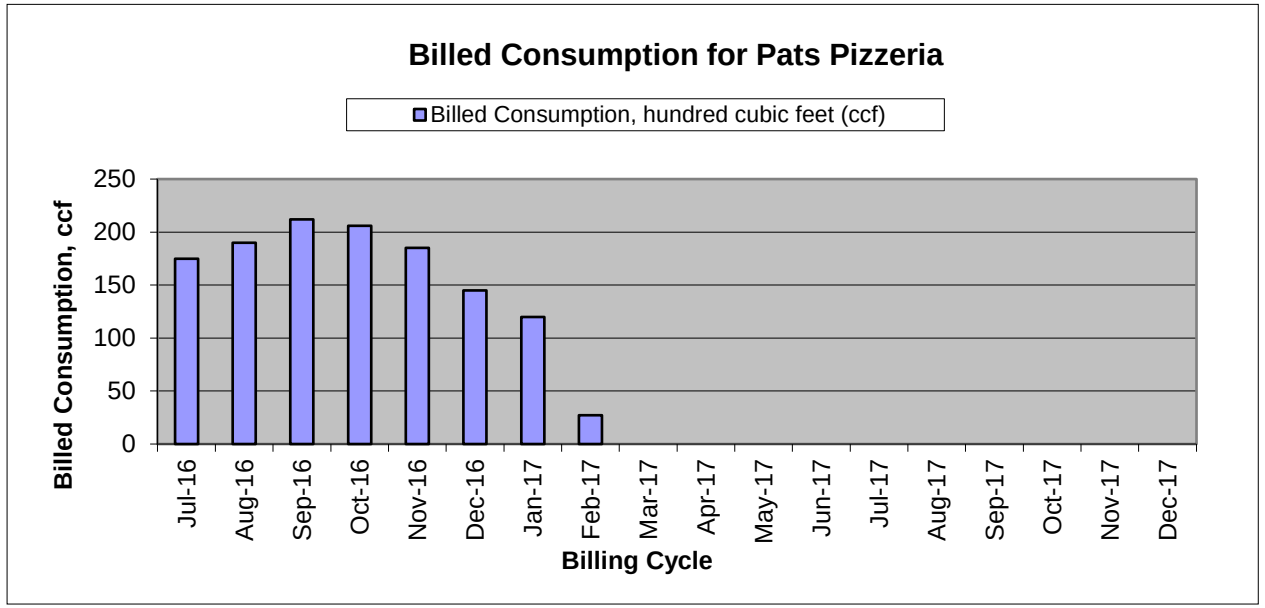
B. Using the AWWA Free Water Audit Software

WORKSHEET – APPARENT LOSSES: UNAUTHORIZED CONSUMPTION (UC)

Tracking Unauthorized Consumption: uncovering when water is taken without payment

- Visual: “caught in the act” but this is “hit or miss”
- Billing records – unusually low or zero water usage
- Tamper alert from automated meter reading systems

Billing trend for pizza shop showing many months of zero consumption



Nail inserted into water meter register to slow the flow registration

B. Using the AWWA Free Water Audit Software

WORKSHEET – QUANTIFYING APPARENT LOSSES

Tracking Unauthorized Consumption: uncovering when water is taken without payment

- Example calculation for discovered instances of unauthorized consumption
  - Three instances of water meters removed & replaced by straight pipe
  - Assume each event ran 6 months (one-half year)
  - Average monthly residential consumption was 3,328 gal
  - Unauthorized consumption volume =

    (3,328 gallons/customer/month) x 3 customers x 6 months =

    59,904 gal = 0.060 mg

KNOWLEDGE CHECK

Calculate the annual volume of water lost to unauthorized consumption as listed below:

Utility staff conducted indoor meter inspections, finding:

- **Three customer meters were found damaged due to tampering**
- **From billing records, the meters were non-functional for 2, 4, and 5 months, respectively**
- **Average residential monthly consumption is 4,500 gallons**
- **Calculate the volume of Unauthorized Consumption and select from the answers to the right**

A. 0.144 million gallons

B. 0.049 million gallons

C. 1.000 million gallons

D. 0.081 million gallons

Answer = _____

B. Using the AWWA Free Water Audit Software

KNOWLEDGE CHECK - ANSWER

Calculate the annual volume of water lost to unauthorized consumption as listed below:

Utility staff conducted indoor meter inspections are found:

- Four customer meters were damaged due to tampering
- From billing records, the meters were found non-functional for 2, 4, and 5 months respectively
- Average residential monthly consumption was 4,500 gallons
- Calculate the volume of Unauthorized consumption and select from the answers to the right

A. 0.144 million gallons

B. 0.049 million gallons

C. 1.000 million gallons

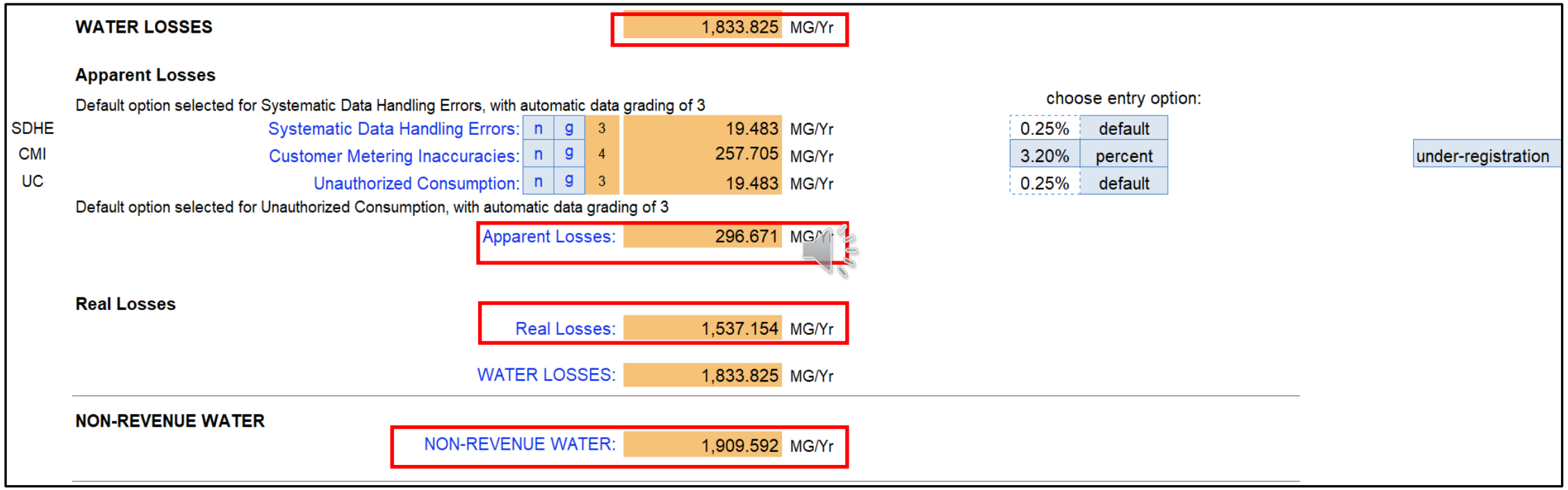
D. 0.081 million gallons

Answer = ___B____

Course 1 Module 2

B. Using the AWWA Free Water Audit Software

WORKSHEET – SUMMARIZING WATER LOSSES AND NON-REVENUE WATER



	WATER LOSSES				1,833.825	MG/Yr			
	Apparent Losses								
	Default option selected for Systematic Data Handling Errors, with automatic data grading of 3						choose entry option:		
SDHE	Systematic Data Handling Errors:	n	g	3	19.483	MG/Yr	0.25%	default	
CMI	Customer Metering Inaccuracies:	n	g	4	257.705	MG/Yr	3.20%	percent	under-registration
UC	Unauthorized Consumption:	n	g	3	19.483	MG/Yr	0.25%	default	
	Default option selected for Unauthorized Consumption, with automatic data grading of 3								
	Apparent Losses:				296.671	MG/Yr			
	Real Losses								
	Real Losses:				1,537.154	MG/Yr			
	WATER LOSSES:				1,833.825	MG/Yr			
	NON-REVENUE WATER								
	NON-REVENUE WATER:				1,909.592	MG/Yr			

Apparent Losses = Systematic Data Handling Error + Customer Metering Inaccuracies + Unauthorized Consumption

Real Losses = Water Losses – minus Apparent Losses

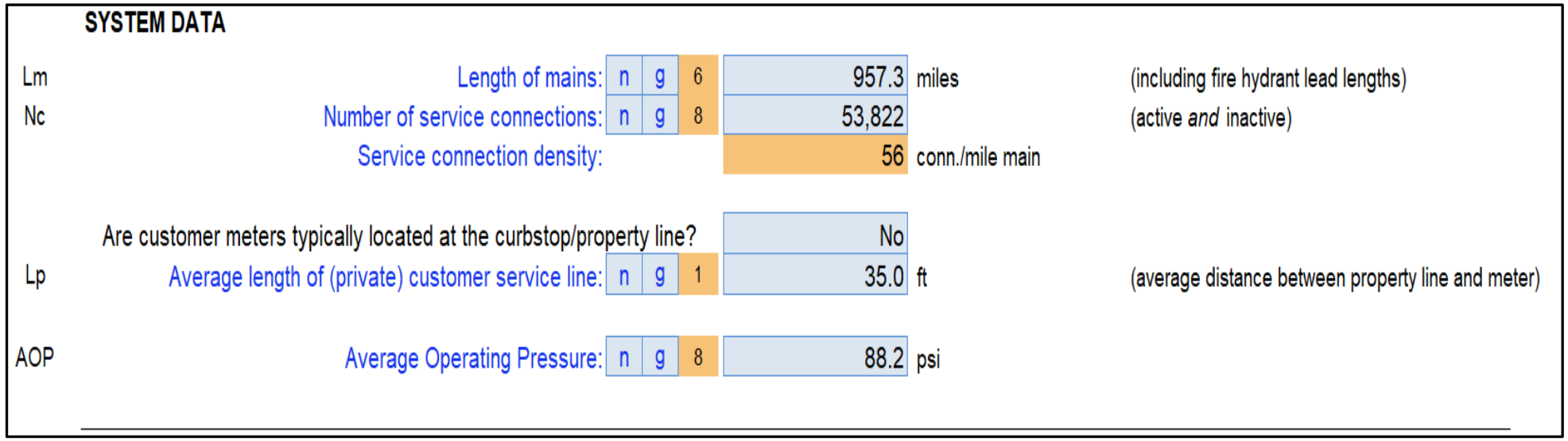
Non-revenue Water = Water Losses + Unbilled Consumption (metered and unmetered)

B. Using the AWWA Free Water Audit Software

WORKSHEET – SYSTEM DATA

The water auditor should enter data for five system parameters, including:

- Length of mains
- Number of active & inactive service connections
- A question on meter location
- Average length of service connection
- Average operating pressure



SYSTEM DATA							
Lm	Length of mains:	n	g	6	957.3	miles	(including fire hydrant lead lengths)
Nc	Number of service connections:	n	g	8	53,822		(active *and* inactive)
	Service connection density:				56	conn./mile main	
	Are customer meters typically located at the curbstop/property line?				No		
Lp	Average length of (private) customer service line:	n	g	1	35.0	ft	(average distance between property line and meter)
AOP	Average Operating Pressure:	n	g	8	88.2	psi	

B. Using the AWWA Free Water Audit Software

WORKSHEET – COST DATA

The water auditor should enter data for three costs, including:

- Customer Retail Unit Charge
- Variable Production Cost
- Total Annual Operating Cost (*optional*)

COST DATA

Customer Retail Unit Charge:	n	g	10	$4.08	$/1000 gallons (US)	
Variable Production Cost:	n	g	3	$521.25	$/Million gallons	

Total Annual Operating Cost

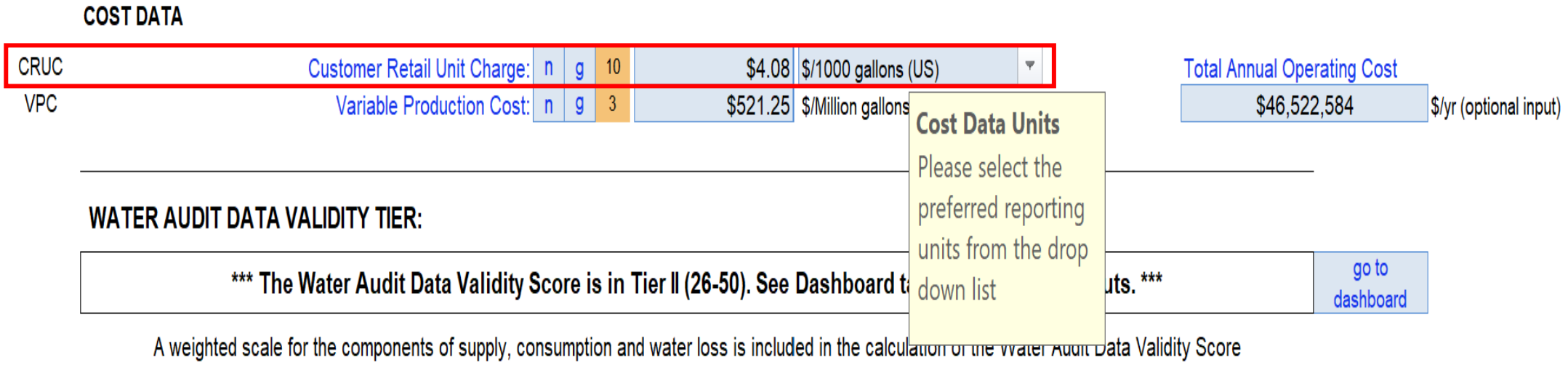
$46,522,584 $/yr (optional input)

These costs are used to calculate financial performance indicators

B. Using the AWWA Free Water Audit Software

WORKSHEET – USING CUSTOMER RETAIL UNIT CHARGE (CRUC) TO APPLY TO APPARENT LOSSES

- CRUC is a unit cost, in dollars per 1,000 gallons, or dollars per 100 cubic feet (ccf), for most USA systems. Select units via the down arrow.
- This is a single, composite rate that you charge your customers
- If distinct charges exist for different customer classes, or different rate tiers exist, they must be consolidated into a single, aggregate rate that is representative for the entire customer population
- If sewer or wastewater charges are also billed based upon the volume of drinking water consumed, the sewer charge should be added



B. Using the AWWA Free Water Audit Software

WORKSHEET – EXAMPLE CALCULATION: APPLYING COSTS TO WATER UTILITY LOSSES

Example calculation: Community Water Authority quantified Apparent Losses of 296.671 mg in its water audit. Its CRUC is $4.08 per 1,000 gallons. The CRUC calculation is given below:

Apparent Losses = 296.671 mg = 296,671 kgal. (Note: 1,000 gallons = 1 kgal)

Apparent Loss Costs = (296,671 kgal)($4.08/kgal) = **$1,210,418**

This is taken as potentially uncaptured revenue for the year. Note: the Software values a portion (unbilled consumption) at the VPC for CMI, giving a slightly lower cost impact of $1,210,051)

Excerpt of the Dashboard Worksheet

Apparent Losses:	296.671	MG/Yr	
Customer Retail Unit Charge:	n g 10	$4.08	$/1000 gallons (US)

	Volume MG/Yr	Value $/Yr
Apparent Losses	296.7	$1,210,051
Real Losses	1,537.2	$801,241
Unbilled Authorized Cons	75.8	$39,494
Non-Revenue Water	1,909.6	$2,050,786

B. Using the AWWA Free Water Audit Software

KNOWLEDGE CHECK – APPARENT LOSS COSTS

A small water utility serving 3,800 people via 1,858 customer connections has Apparent Losses of 30,000 mg. Its Customer Retail Unit Cost is $17.00* per 1,000 gallons.

- Calculate the basic cost impact of the apparent losses and select the correct answer from the list to the right

A. $510,000,000

B. $510,000

C. $510

Answer = _____

*The CRUC of this water utility is very high because sewer charges of $12.00 per 1,000 gallons are included in the monthly bill along with water service charges of $5.00 per 1,000 gallons

B. Using the AWWA Free Water Audit Software

KNOWLEDGE CHECK - ANSWER

A small water utility serving 3,800 people via 1,858 customer connections has apparent losses of 30.000 mg. Its Customer Retail Unit Cost is $17.00* per 1,000 gallons.

- Calculate the basic cost impact of the apparent losses and select the correct answer from the list to the right

A. $510,000,000

B. $510,000

C. $510

Answer = ___B____

*The CRUC of this water utility is very high because sewer charges of $12.00 per 1,000 gallons are included in the monthly bill along with water service charges of $5.00 per 1,000 gallons

B. Using the AWWA Free Water Audit Software

WORKSHEET – VARIABLE PRODUCTION COST (VPC) ASSIGNED TO REAL LOSSES

- The VPC is a unit cost in dollars per million gallons, for water audits compiled in gallons units
- The VPC is often assigned to value real (leakage) losses
- It includes only ***variable*** costs, or those costs that vary as the production flows vary
  - These include primarily electric power used to pump water and treatment chemical costs
  - These costs do not include fixed costs such as employee salaries, equipment, or most materials

COST DATA

Customer Retail Unit Charge:	n	g	10	$4.08	$/1000 gallons (US)
Variable Production Cost:	n	g	3	$521.25	$/Million gallons

B. Using the AWWA Free Water Audit Software

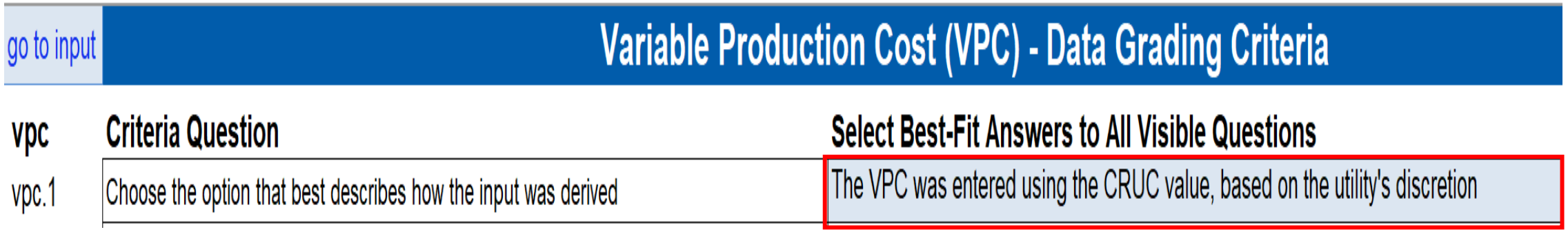
WORKSHEET – VARIABLE PRODUCTION COST ASSIGNED TO REAL LOSSES

Variable Production Cost – additional notes

- If a water utility purchases its water supply as Imported water, the unit cost for this water should be input into the cell for Variable Production Cost.
- The imported water cost is usually defined in the contract for water service

Option to Select the Customer Retail Unit Charge applied to leakage

- Select this option in Question 1 of the Interactive Data Grading Matrix worksheet if water resources are scarce and customer demand may outpace supply



go to input	Variable Production Cost (VPC) - Data Grading Criteria	
vpc	Criteria Question	Select Best-Fit Answers to All Visible Questions
vpc.1	Choose the option that best describes how the input was derived	The VPC was entered using the CRUC value, based on the utility's discretion

B. Using the AWWA Free Water Audit Software

WORKSHEET – VARIABLE PRODUCTION COST CALCULATION EXAMPLE

Cost data for Community Water Authority was taken from its revenue & expense report, giving:

- Treatment chemical cost: $1,868,607.
- Electricity: $4,252,053. This is for all electrical use. Six pumping stations provide treated water pumping to the distribution system. It was assumed that 75% of the utility's electrical use is for pumping. Pumping power costs = ($4,252,053)(0.75) = $3,189,040
- The Water Supplied Volume for the utility was 9,702.921 million gallons
- The VPC equals = ($1,868,607 + $3,189,040)/ 9,702.921 mg = **$521.25 per million gallons**

COST DATA

Customer Retail Unit Charge:	n	g	10	$4.08	$/1000 gallons (US)
Variable Production Cost:	n	g	3	$521.25	$/Million gallons

B. Using the AWWA Free Water Audit Software

WORKSHEET – VPC CALCULATION KNOWLEDGE CHECK

The water audit process for a water utility with 2,100 service connections found:

- Treatment chemical costs: $210,000
- Electric power costs: $850,000
- Assume that 80% of electric cost went to pumping
- Water Supplied volume of 1,250.000 million gallons

Use these numbers to calculate the Variable Production Cost (VPC).

Select the correct answer from the top box and type it in the bottom box

a. $1,133 / mg
b. $848 / mg
c. $712 / mg
d. $680 / mg

Answer = _____

B. Using the AWWA Free Water Audit Software

REPORTING WORKSHEET – VPC CALCULATION KNOWLEDGE CHECK

The water audit process for a small water utility with 2,100 service connections found:

- Treatment chemical costs: $210,000
- Electric power costs: $850,000
- Assumed that 80% of electric cost went to pumping
- Water Supplied volume of 1,250.000 million gallons

Use these numbers to calculate the Variable Production Cost (VPC).

Select the correct answer from the top box and type it in the bottom box

a. $1,133 / mg
b. $848 / mg
c. $712 / mg
d. $680 / mg

Answer = __C__

B. Using the AWWA Free Water Audit Software

WORKSHEET – TOTAL ANNUAL OPERATING COST

In the Version 6.0 AWWA Free Water Audit Software, this is an optional input

- The annual costs of day-to-day operations and maintenance as well as long-term financing for the water system only
- Costs include employee salaries, materials, equipment, contract services, other water costs
- Do not include any costs for sewer, biosolids, or other systems of non-potable water
- This parameter is not used in calculating any performance indicators

COST DATA

Customer Retail Unit Charge:	n	g	10	$4.08	$/1000 gallons (US)
Variable Production Cost:	n	g	3	$521.25	$/Million gallons

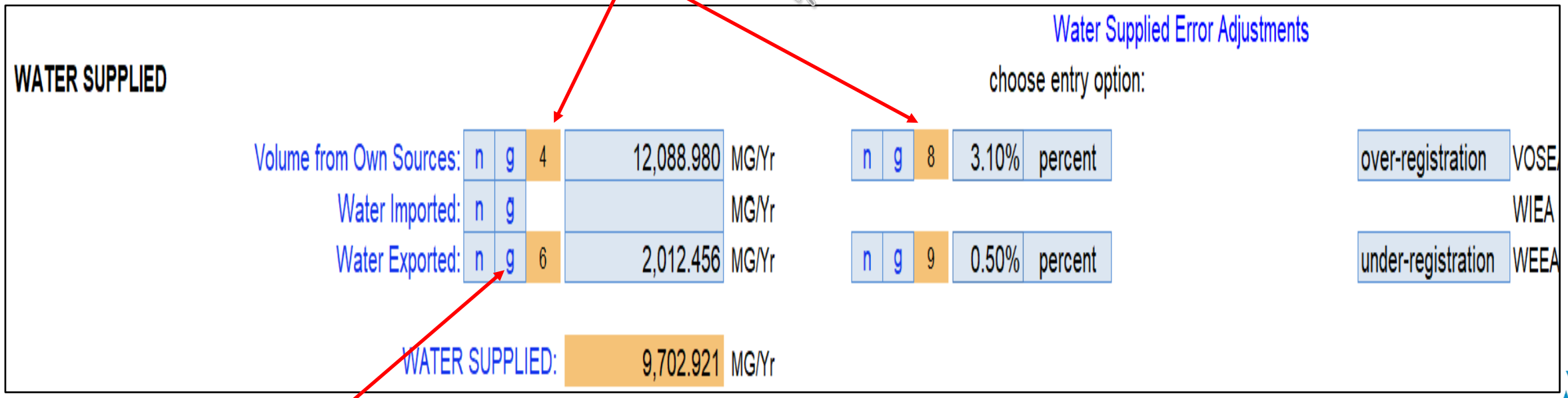
Total Annual Operating Cost	
$46,522,584	$/yr (optional input)

Now, let's move on to assign data gradings to our data inputs……

C. Interactive Data Grading Feature

WORKSHEET – WATER SUPPLIED SECTION

Data Gradings – Every data input is also assigned a grading that reflects the trustworthiness of the data. Gradings are a rating of data quality and based on a scale of 1 to 10, with a 1 being data that is a very rough estimate and a 10 a very reliable number. The gradings are assigned by the Software based upon answers to questions provided by the auditor on the Interactive Data Grading worksheet. The assigned gradings are displayed on the worksheet.



Navigate to the Interactive Data Grading worksheet by clicking on the “g” icon

Course 1 Module 2

C. Data Grading and the Data Validity Score

INTERACTIVE DATA GRADING WORKSHEET

Community Water Authority
2020

AWWA Free Water Audit Software: Interactive Data Grading

VOS | VOSEA | WI | WIEA | WE | WEEA | BMAC | BUAC | UMAC | UUAC
SDHE | CMI | UC | Lm | Nc | Lp | AOP | CRUC | VPC

acronym key

White = incomplete
Orange = complete
Use acronyms for navigation

Limiting criteria (see Start Page for details)

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go to input | Volume from Own Sources (VOS) - Data Grading Criteria | go to notes

vos	Criteria Question	Select Best-Fit Answers to All Visible Questions	
vos.0	Did the water utility supply any water from its own sources during the audit year?	Yes	
vos.1	What percent of own supply volume is metered?	>99%	
	For questions 2-10 below: Choose the answer that applies for those meters that measure >90% of the finished water volume. **In-situ flow accuracy testing** = a test process that confirms the flow measuring accuracy of the primary device (the flowmeter), in its installed location, using an independent reference volume. **Electronic calibration** = a process that checks for error in the metering secondary device(s) and/or the tertiary device(s). **Secondary device** can include conversion to mA, meter transmitter or similar instrumentation. **Tertiary device** can include SCADA, historian or other computerized archival system.		
vos.2	What is the frequency of electronic calibration?	Annually	
vos.3	What level of data transfer errors are checked as part of the electronic calibration process?	Data transfer errors are not checked, or not sure	Limiting
vos.4	Is the most recent electronic calibration documentation available for review?	Yes	
vos.5	What is the frequency of in-situ flow accuracy testing?	Less than annual but within last 5 years	
vos.6	Is the most recent in-situ flow accuracy testing documentation available for review?	Yes	
vos.7	What are the total volume-weighted average results of in-situ flow accuracy testing (during or closest to audit year)?	Between ±3% to ±6%	
vos.8	Have testing and calibration procedures been closely scrutinized for compliance with procedures described in the AWWA M36 and/or M33 Manual(s)?	No	
vos.9	Which best describes the frequency of finished water meter readings?	Continuous	
vos.10	Which best describes the frequency of data review for anomalies/errors? These can include numbers that are outside of typical patterns, and zero or 'null' values that may reflect a gap in data recording.	Once per month	
	FINAL DATA GRADE FOR THIS AUDIT INPUT:	4	

vos.7	What are the total volume-weighted average results of in-situ flow accuracy testing (during or closest to audit year)?	
vos.8	Have testing and calibration procedures been closely scrutinized for compliance with procedures described in the AWWA M36 and/or M33 Manual(s)?	At ±6% or greater Between ±3% to ±6% At or within ±3%

Interactive Data Grading:

- The auditor answers a series of questions
- Select the best-fit answer from the Drop-down menu of each question
- The label "Limiting" denotes the question that fixes the final grading of "4"

Drop-down menu for question vos. 7

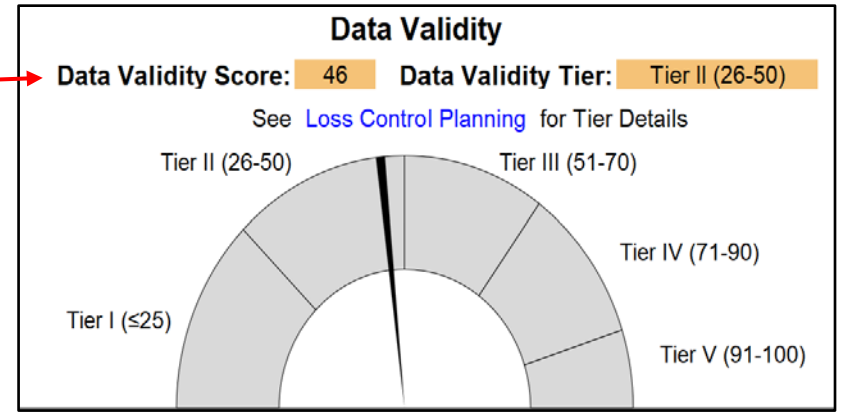
C. Data Grading and the Data Validity Score

WORKSHEET – WATER AUDIT DATA VALIDITY SCORE AND DATA VALIDITY TIER

Data Validity Score (DVS): composite calculation based upon individual grading values

- Based upon a scale from 10-100
- Represents the validity, or trustworthiness, of the entire water audit

Data Validity Tier (DVT): each of five groupings in the range of DVS



Top Left Portion of the Dashboard worksheet

WATER AUDIT DATA VALIDITY TIER:

*** The Water Audit Data Validity Score is in Tier II (26-50). See Dashboard tab for additional outputs. *** | go to dashboard

A weighted scale for the components of supply, consumption and water loss is included in the calculation of the Water Audit Data Validity Score

PRIORITY AREAS FOR ATTENTION TO IMPROVE DATA VALIDITY:

Based on the information provided, audit reliability can be most improved by addressing the following components:

1: Volume from Own Sources (VOS)
2: Billed Unmetered (BUAC)
3: Billed Metered (BMAC)

KEY PERFORMANCE INDICATOR TARGETS:

OPTIONAL: If targets exist for the operational performance indicators, they can be input below:

Unit Total Losses:		gal/conn/day
Unit Apparent Losses:		gal/conn/day
Unit Real Losses[A]:		gal/conn/day
Unit Real Losses[B]:		gal/mile/day

If entered above by user, targets will display on KPI gauges (see Dashboard)

Priority Areas for Attention: the top three components that are a good focus for improved data quality.

Utility's Targets *(optional)*

Bottom Portion of the "Worksheet"

C. Data Grading and the Data Validity Score

LOSS CONTROL PLANNING WORKSHEET – *WHAT DOES THE DVS MEAN FOR MY UTILITY?*

AWWA Free Water Audit Software:
Determining Water Loss Standing

FWAS v6.0

Water Audit Report for: Community Water Authority
Audit Year: 2020 Jan 01 2020 - Dec 31 2020
Data Validity Tier: Tier II (26-50)

Water Loss Control Planning Guide

Functional Focus Area	Water Audit Data Validity Tier (Score Range)				
	Tier I (1-25)	Tier II (26-50)	Tier III (51-70)	Tier IV (71-90)	Tier V (91-100)
Audit Data Collection	Launch auditing and loss control team; address supply metering deficiencies	Analyze business process for customer metering and billing functions and water supply operations; identify data gaps; improve supply metering	Establish/revise policies and procedures for data collection	Refine data collection practices and establish as routine business process	Annual water audit is a reliable gauge of year-to-year water efficiency standing
Short-term loss control	Research information on leak detection programs; Begin flowcharting analysis of customer billing system	Conduct loss assessment investigations on a sample portion of the system: customer meter testing, leak survey, unauthorized consumption, etc	Establish ongoing mechanisms for customer meter accuracy testing, active leakage control and infrastructure monitoring	Refine, enhance or expand ongoing programs based upon economic justification	Stay abreast of improvements in metering, meter reading, billing, leakage management and infrastructure rehabilitation
Long-term loss control		Begin to assess long-term needs requiring large expenditure: customer meter replacement, water main replacement program, new customer billing system or AMR/AMI system	Begin to assemble economic business case for long-term needs based upon improved data becoming available through the water audit process	Conduct detailed planning, budgeting and launch of comprehensive improvements for metering, billing or infrastructure management	Continue incremental improvements in short-term and long-term loss control interventions
Target-setting			Establish long-term apparent and real loss reduction goals (+10 year horizon)	Establish mid-range (5 year horizon) apparent and real loss reduction goals	Evaluate and refine loss control goals on a yearly basis
Benchmarking			Preliminary Comparisons - can begin to rely upon with PIs for performance comparisons for real losses	Performance Benchmarking with PIs is meaningful in comparing real loss standing	Identify Best Practices/ Best in class; PIs are very reliable as real loss performance indicators for best in class service

For validity scores of 50 or below, the shaded blocks should not be focus areas until better data validity is achieved.

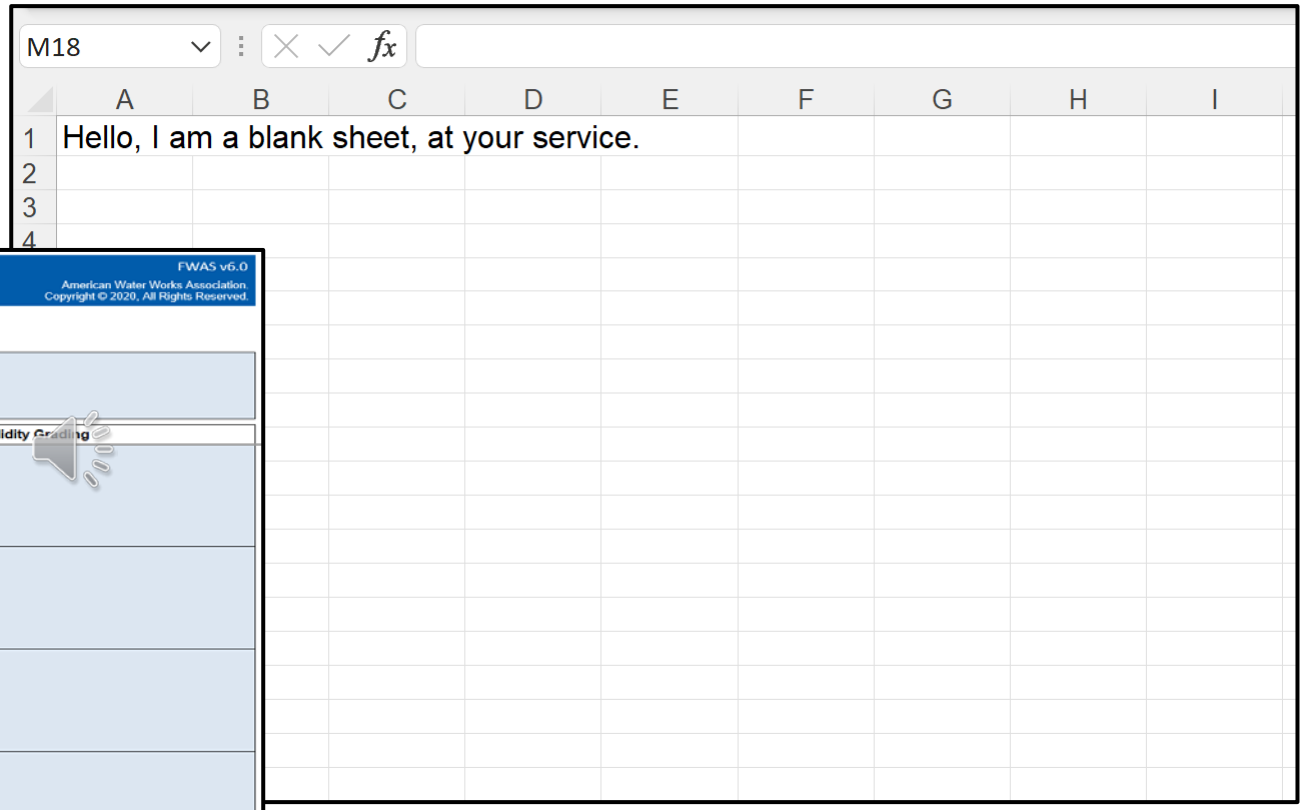
Water Loss Control Planning Guide:

- Gives guidance on interpretation of the Data Validity Score (DVS) shown in the five tiers
- Represents a continuum of process-based assessments
- Higher validity = more reliable assessment of water loss standing and greater loss control opportunities

Course 1 Module 2

C. Additional Features of the AWWA Free Water Audit Software

Worksheets that aid the documentation of the water audit process



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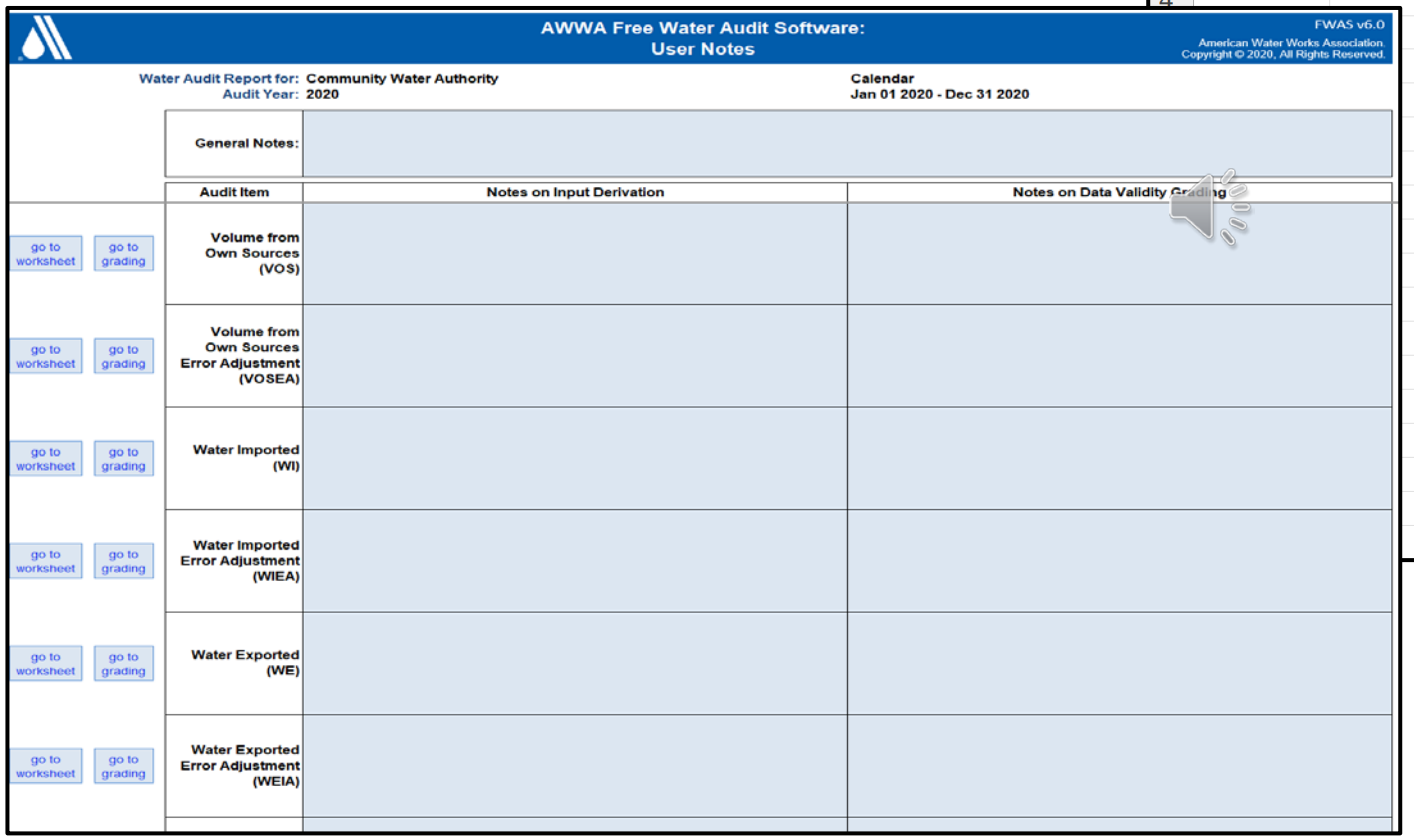


Notes Worksheet

D. The Compiler Software

The Software, also available for free download, allows data from multiple water audits to be assembled, or 'compiled,' into a single spreadsheet. This is useful for:

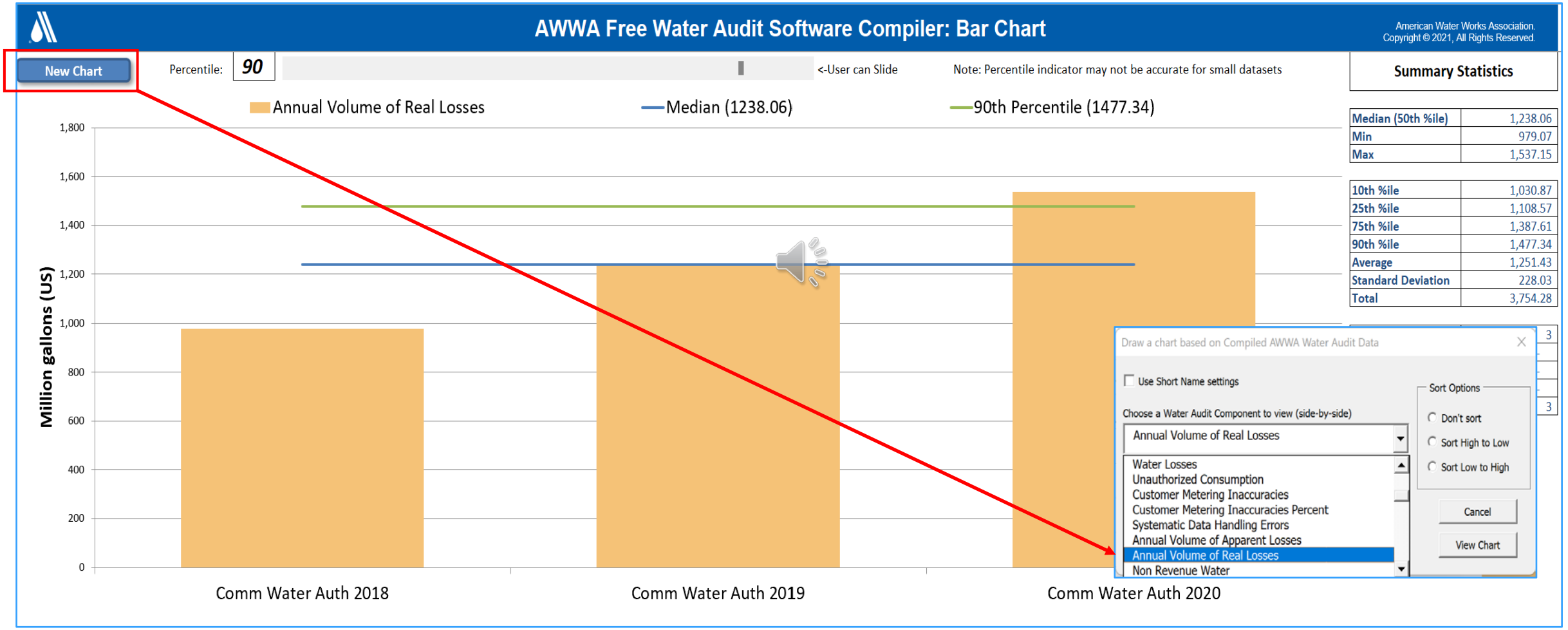
- Assembling audits of multiple years from a single water utility
- Assembling audits from a single year for many water utilities

Include on Chart	Run Compiler / View Name of City / Utility:	Volume From Own Sources	Volume From Own Sources MMEA	Water Imported	Water Imported MMEA	Water Exported	Water Exported MMEA	Water Supplied
Yes	Comm Water Auth 2018	11,678.780	58.103		-	2,034.287	(10.223)	9,576.167
Yes	Comm Water Auth 2019	11,972.230	359.980		-	1,983.892	(9.969)	9,618.389
Yes	Comm Water Auth 2020	12,088.980	363.490		-	2,012.456	(10.113)	9,702.921

Excerpt of the 'Data' Worksheet of the Compiler Software

D. The Compiler Software

Compiler reveals trend of increasing real losses for Community Water Authority from 2018-2020



Compiler 'Side-by-Side' Worksheet showing the Annual Volume of Real Losses for Community Water Authority

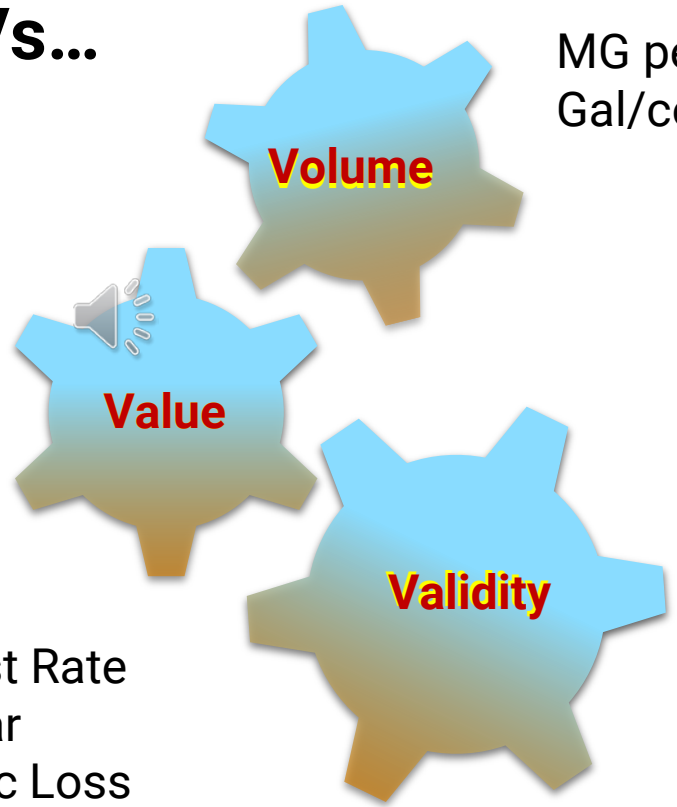
Course 1 Module 2 Summary

Module 2 covered the AWWA Free Water Audit Software, including:

- **How to obtain the Software and navigate through it**
- **Inputting the data, including water volumes, system data, and costs**
- **How to answer questions that allow the Software to assign a data grading to each input, and calculate the Data Validity Score**

Best approach to the water audit; focus on the - -

Three Vs…



MG per Year
Gal/connection/day

Loss Cost Rate
$ per Year
Economic Loss
Real and Apparent

Data Input Grading
Water Audit Data Validity Score

MODULE 3

Using Performance Indicators to Track Progress in Controlling Non-revenue Water

Module 3 Agenda

A. Defining Performance Indicators

B. AWWA's System Attributes & Performance Indicators

C. Using the AWWA Performance Indicators

D. The Problems with Percentage Indicators

E. Comparing Indicators with Other Water Utilities

Learning Objectives

As a result of Module 3 participants will be able to:

1. Identify what performance indicators are and how they are used
2. Employ AWWA's performance indicators
3. Recognize the weaknesses of percentage indicators
4. Compare a utility's indicators to a recognized dataset of many systems

A. Defining Performance Indicators

Performance Indicators are used constantly in everyday society

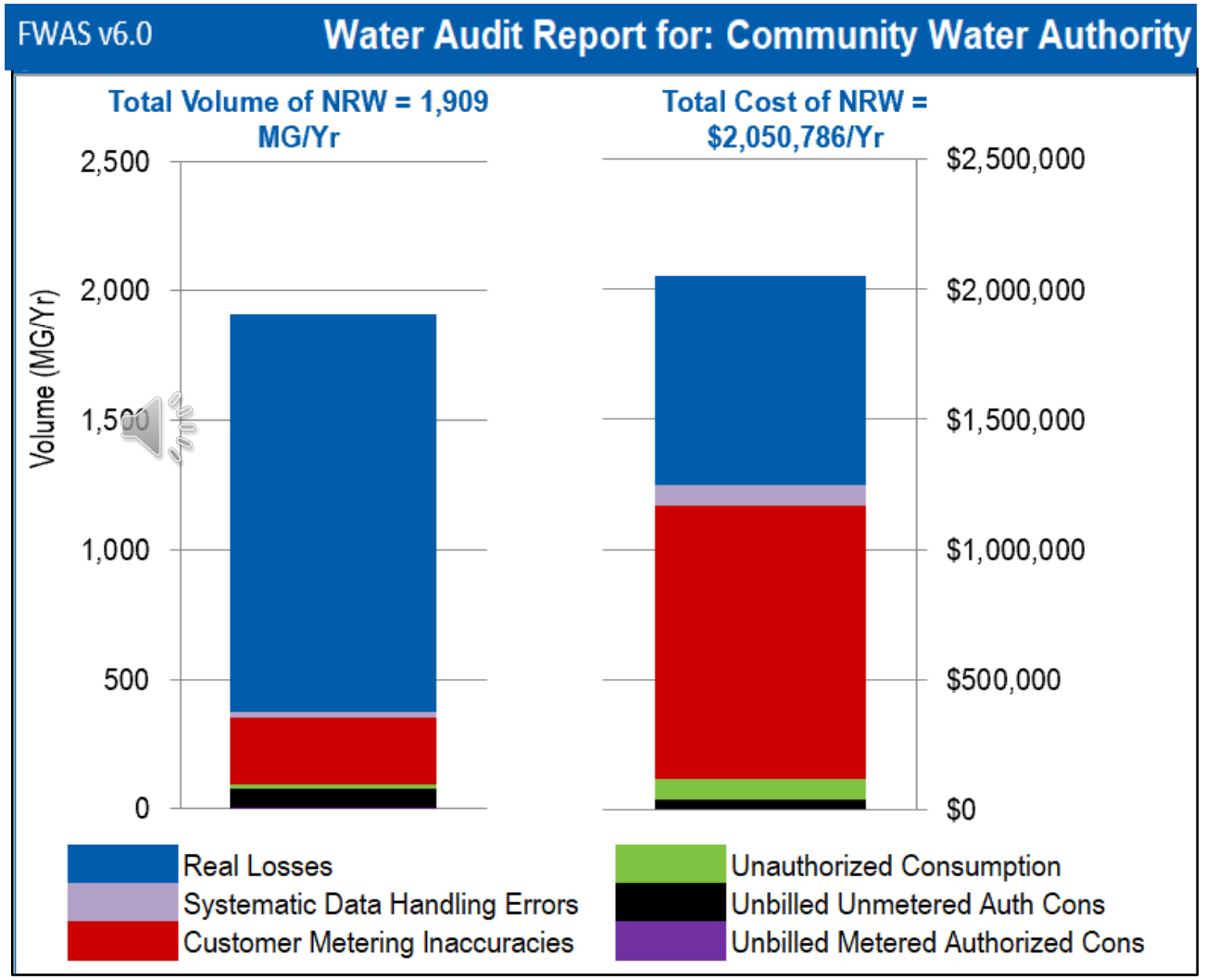
Weather	High/low temperatures, rainfall, snowfall, wind, storms
Sports	Batting averages, home runs, touchdowns, yards passing or rushing, goals, points per game
Health	Blood pressure, temperature, cholesterol, blood **sugar**
Business	Sales, revenue, cash flow, inventory, inflation rate
Consumer	4-star or 5-star ratings and user reviews for restaurants, hotels, movies, music, stores, contractors, services

B. AWWA's System Attributes & Performance Indicators

AWWA's System Attributes:

- Numeric values that are characteristic of your system alone
- Good for tracking your year-to-year performance
- Less useful for comparisons with other systems

	Volume MG/Yr	Value $/Yr	Basis of Valuation
Apparent Losses	296.7	$1,210,051	CRUC
Real Losses	1,537.2	$801,241	VPC
Unbilled Authorized Cons	75.8	$39,494	VPC
Non-Revenue Water	1,909.6	$2,050,786	Blended



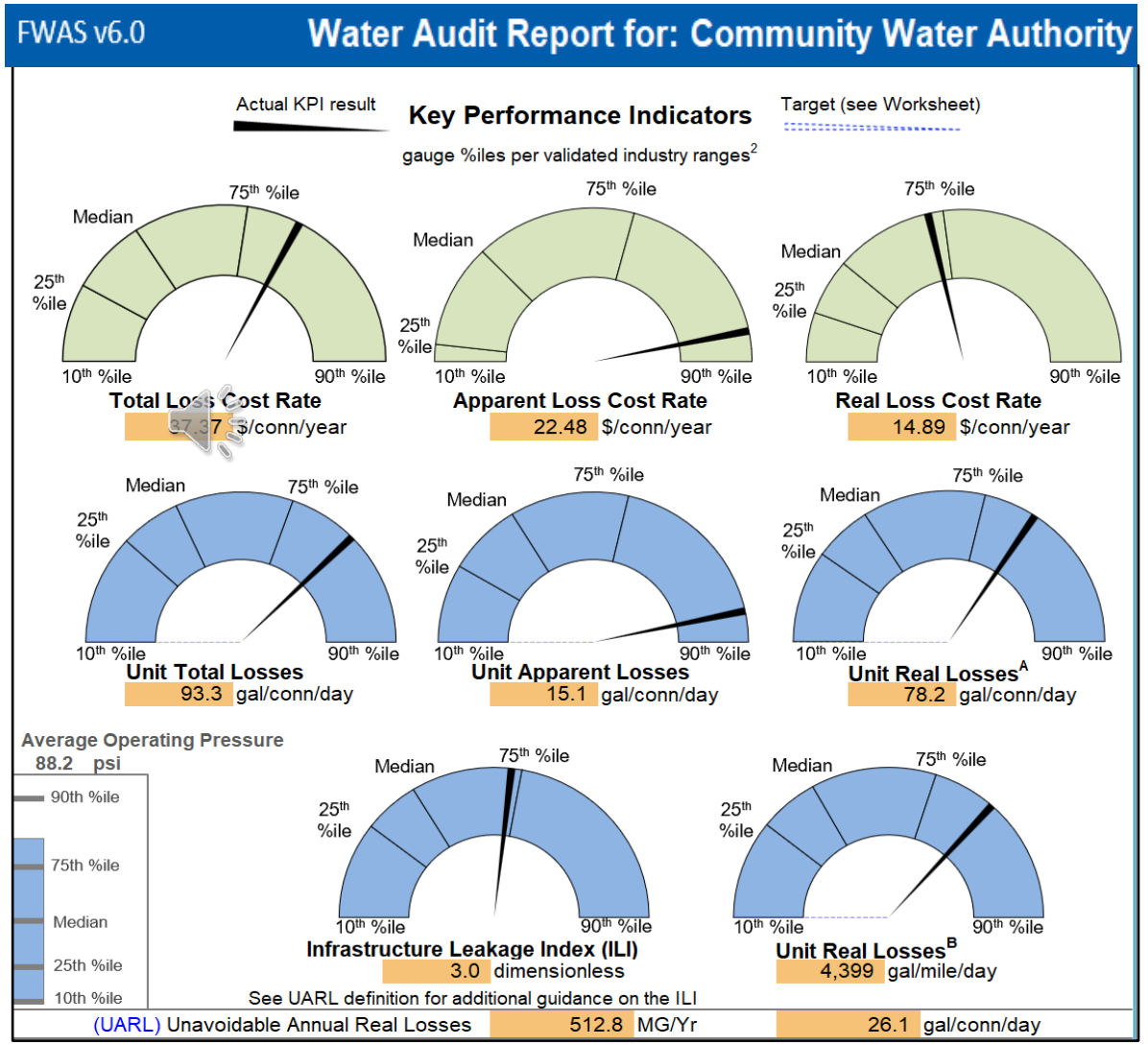
Excerpts of the Dashboard Worksheet

Course 1 Module 3

B. AWWA's System Attributes & Performance Indicators

AWWA's Performance Indicators:

- Numeric values that are useful for performance tracking and comparisons with other utilities
- Using Percentiles: Ex. For 90th percentile, only 10% of utilities have a higher value than the 90th percentile value
- Certain indicators are designed for benchmarking, or comparisons with "best-in-class" water utilities



Excerpt of the Dashboard Worksheet – Top Portion

Course 1 Module 3

C. Using the AWWA Performance Indicators

Table 1 Source: AWWA Water Loss Control Committee Report (2020)[1], with naming conventions updated

2020 AWWA Water Audit Method – Water Audit Outputs and Key Performance Indicators: Uses and Limitations

Type	Indicator	Description	Suitable Purposes					Uses and Limitations	Principal Users
			Assessment	Bench-Marking	Target-Setting	Planning	Tracking		
Attribute	Apparent Loss Volume	Calculated by Free Water Audit Software	✓				✓	Assess loss level	Utility, Regulators
	Apparent Loss Cost	Calculated by Free Water Audit Software	✓				✓	Assess cost loss level	Utility, Regulators
	Real Loss Volume	Calculated by Free Water Audit Software	✓				✓	Assess loss level	Utility, Regulators
	Real Loss Cost	Calculated by Free Water Audit Software	✓				✓	Assess loss cost level	Utility, Regulators
	Unavoidable Annual Real Loss (UARL)	Calculated by Free Water Audit Software	✓				✓	Reveal theoretical technical low level of leakage	Utility, Regulators
Volume	Unit Apparent Losses (vol/conn/day)	Strong and understandable indicator for multiple users.	✓	✓	✓	✓	✓	Used for performance tracking and target-setting	Utility, Regulators
	Unit Real Losses[A] (vol/conn/day)	Strong and understandable indicator for multiple users.	✓	✓	✓	✓	✓	Used for performance tracking and target-setting	Utility, Regulators, Policy Makers
	Unit Real Losses[B] (vol/pipeline length/ day)	Strong and understandable indicator for use by utilities with low connection density.	✓	✓	✓	✓	✓	Data collection and assessment of systems with "low" connection density	Utility, Regulators, Policy Makers
	Unit Total Losses (vol/conn/day) **New KPI**	Strong and understandable indicator, suitable for high-level performance measurement.	✓				✓	High level indicator for trending analysis. Not	Utilities, Customers
	Infrastructure Leakage Index (ILI)	Robust, specialized ratio KPI; can be influenced by pressure and connection density.	✓	✓					
Value	Apparent Loss Cost Rate (value/conn/year) **New KPI**	Indicators with sufficient technical rigor. Provide the unit financial value of each type of loss, which is useful for planning and assessment of cost efficiency of water loss reduction and control interventions and programs.	✓						
	Real Loss Cost Rate (value/conn/year) **New KPI**		✓						
Validity	Data Validity Tier (DVT)	Strong indicator of water loss audit data quality, if data has been validated. Tier provides guidance on priority areas of activity.	✓	✓					

Guidance Information for Key Performance Indicators

- The eight indicators shown are the recommended suite per the AWWA Water Loss Control Committee 2020 Position on KPIs[1].
- A suite of KPIs is necessary, as no single KPI can wholistically communicate water loss performance for a given water system.
- See Table 1 below for Uses and Limitations for each KPI, excerpted from the AWWA Water Loss Control Committee Report (2020)[1], with naming conventions updated.
- %iles shown on KPI gauges come from Level 1 validated data in the AWWA WLCC Reference Water Audit Dataset (2020)[2].
- KPI %iles shown above are not segregated by cohorts. Limited KPI data by cohorts may be found in WRF 4695 Guidance Manual, Appendix B (2019)[5].
- Actual KPI results that fall below 10th %ile or above 90th %ile do not necessarily imply error, but should be viewed with scrutiny.
- Percentiles not intended to imply targets. Targets may be input by user for operational KPIs, if desired, on Worksheet.
- See UARL and ILI in Definitions tab for discussion of size and pressure limitations.
- Systems that fall on the extreme ends of size or connection density should use caution when interpreting Unit Losses KPIs.

Excerpt of the Dashboard Worksheet – Bottom Portion

C. Using the AWWA Performance Indicators

Knowledge Check

Which of the below represents information that applies to your water system but is less effective for comparisons?

System Attribute

Performance Indicators

C. Using the AWWA Performance Indicators

Knowledge Check

Which of the below represents information that applies to your water system but is less effective for comparisons?

System Attribute

Performance Indicators

C. Using the AWWA Performance Indicators

Knowledge Check

Which of the below is not a System Attribute in the AWWA Free Water Audit Software?

a. Annual cost of Apparent Losses
b. Apparent Loss volume
c. Infrastructure Leakage Index (ILI)
d. Real (leakage) Loss volume

C. Using the AWWA Performance Indicators

Knowledge Check

Which of the below is not a System Attribute in the AWWA Free Water Audit Software?

a. Annual cost of Apparent Losses
b. Apparent Loss volume
c. **Infrastructure Leakage Index (ILI)**
d. Real (leakage) Loss volume

D. The Problems with Percentage Indicators

The "unaccounted-for" water percentage (UFW%) is a weak indicator because:

- It doesn't express how much loss occurs by water volume
- It doesn't breakdown the specific volumes of apparent loss, real loss, and unbilled authorized consumption
- It doesn't reveal the costs of losses
- It is mathematically affected by changing levels of customer consumption across years

AWWA does not support the use of percentage indicators for Non-revenue Water assessments

D. The Problems with Percentage Indicators

Skewed UFW%

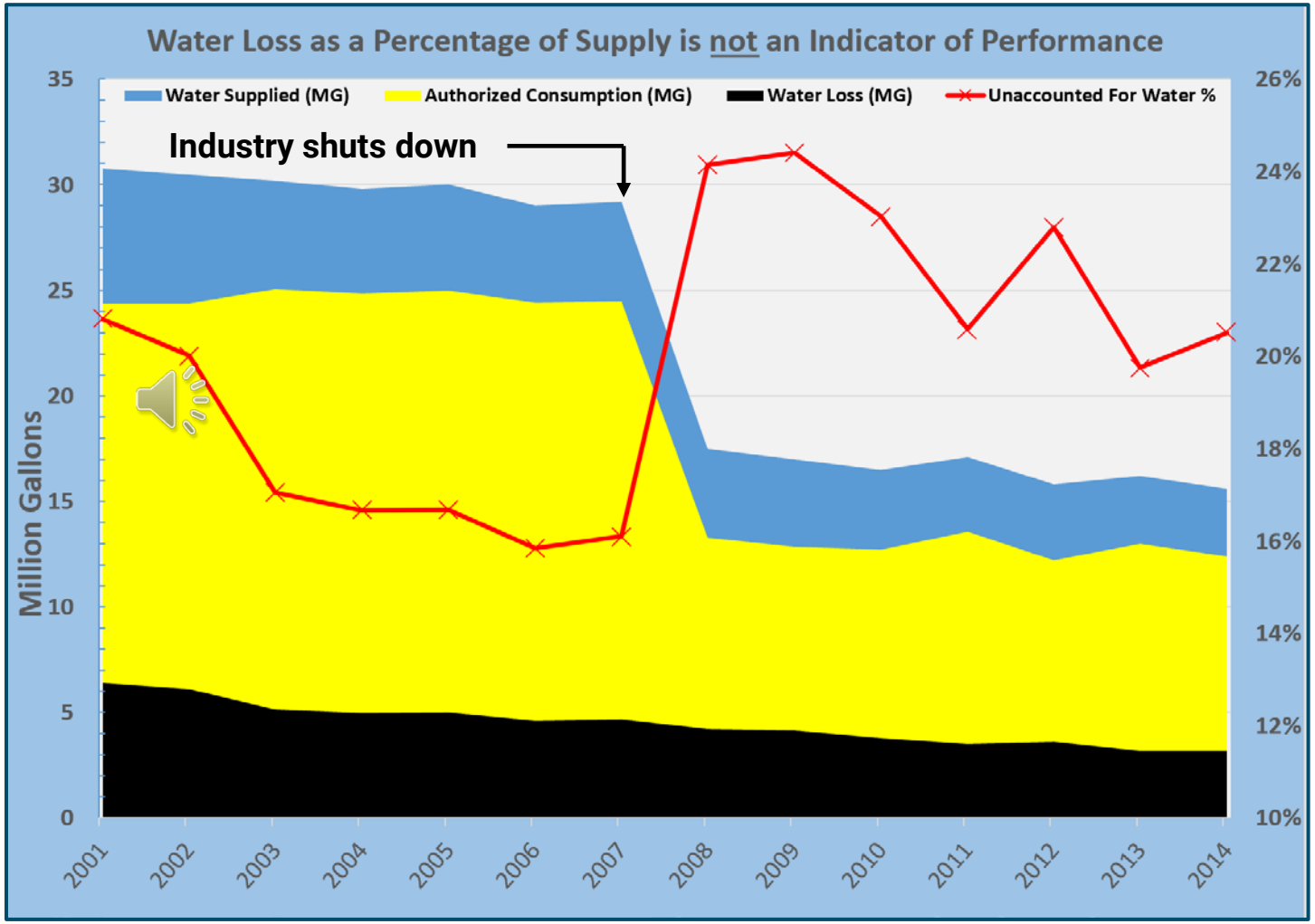
An Example:

Consider a large change in customer consumption due to a major water user (industry) halting operations

The UFW% (red line) increases dramatically, but…

Water losses by volume (black graph) continue to drop!

Thus, the UFW% misrepresents the water loss reduction that occurred



Courtesy of Will Jernigan, P.E. and Cavanaugh Solutions

Course 1 Module 3

E. Comparing Indicators with Other Water Utilities

AWWA Water Audit Reference Dataset (WARD) Summary Data Spreadsheet

AWWA Water Audit Reference Dataset (WARD) Summary Statistics

American Water Works Association - Water Loss Control Committee
George Kunkel, Will Jernigan, Gary Trachtman

March 30, 2021

	SUMMARY STATISTICS	Volume From Own Sources (VOS), mg	Volume From Own Sources Error Adjustment (VOSEA), mg	Water Imported (WI), mg	Water Imported Error Adjustment (WIEA), mg	Water Exported (WE), mg	Water Exported Error Adjustment, (WEEA), mg	Water Supplied (mg / Year)
1,124 Entries in Dataset	Total	1,403,528.086	556.105	530,843.401	-752.023	88,000.404	-216.860	1,848,748.314
	Min	0.000	-214.109	0.000	-331.065	0.000	-116.636	1.094
	Max	111,811.000	1,729.270	47,785.439	21.832	10,077.193	4.982	156,725.781
	10th Percentile	0.000	0.000	0.000	0.000	0.000	0.000	9.216
	25th Percentile	10.931	0.000	0.000	0.000	0.000	0.000	28.947
	Median (50th Percentile)	89.232	0.000	0.000	0.000	0.000	0.000	205.923
	75th Percentile	705.154	0.000	31.716	0.000	0.000	0.000	1,112.721
	90th Percentile Value	2,767.278	0.000	992.456	0.000	51.375	0.000	4,033.765
	Average	1,255.392	0.601	478.669	-0.812	79.783	-0.234	1,644.794
	Standard Deviation	4,932.239	59.013	2,071.881	12.204	498.278	4.638	6,124.431
	Count (1,124 utilities in dataset)	1,118	926	1,109	926	1,103	926	1,124
	Count = 0.00	153	799	741	866	869	913	0
	Count < 0.00	0	74	0	34	0	8	0
	Count > 0.00	965	53	368	26	234	5	1,124
	Data Breakdown for select parameters ->							
Zero or negative summary values are explained with notes in this row.			Negative numbers represent flowmeter over-registration, which is common in many systems		Negative numbers represent flowmeter over-registration, which is common in many systems		Negative numbers represent flowmeter over-registration, which is common in many systems	

THE WARD

- Spreadsheet with summary data available for free download from the AWWA website
- Validated 2018 data for 1,124 utilities from Georgia, California, and Quebec
- WARD values are embedded in the “Speedometer” charts of the V6.0 Dashboard

E. Comparing Indicators with Other Water Utilities

AWWA Water Audit Reference Dataset (WARD)
Range of Performance Indicators Shown as Five Percentile Values
USA Customary Units

Performance Indicator	Units	AWWA WARD 2018 (1,124 Systems) 10th	25th	50th (median)	75th	90th
Customer Retail Unit Charge	$/1,000 gal	$2.05	$2.89	$4.40	$6.43	$8.67
Variable Production Cost	$/million gallons	$170.37	$273.62	$529.07	$1,079.09	$1,997.24
Total Loss Cost Rate	$/conn/yr	$5.08	$9.33	$18.28	$31.58	$57.80
Apparent Loss Cost Rate	$/conn/yr	$0.27	$0.87	$6.15	$14.13	$24.23
Real Loss Cost Rate	$/conn/yr	$1.90	$3.73	$7.95	$16.29	$35.55
Unit Total Losses	gal/conn/day	21.1	29.5	45.4	76.2	125.2
Unit Apparent Losses	gal/conn/day	1.2	2.8	5.3	9.4	16.3
Unit Real Losses	gal/conn/day	16.3	22.7	36.8	66.4	115.4
Infrastructure Leakage Index,	dimensionless	0.9	1.2	1.8	3.2	5.7
Unit Real Losses	gal/mile/day	879	1,289	2,049	3,640	6,074

Where does my system fall compared to the water utilities of the WARD?

- Compile the water audit using the V6.0 AWWA Free Water Audit Software
- Review the Speedometer charts on the Dashboard Worksheet, or refer to the WARD Summary Data spreadsheet

Module 3 Summary:

The Version 6.0 AWWA Free Water Audit Software offers improved Non-revenue Water performance indicators

Percentage indicators are misleading and AWWA does not support their use

A large datasets of validated water audit data – the WARD – exists and can give utilities a representative portrayal of the range of loss and cost values occurring in the drinking water industry

You can compare the water audit data of your water utility to range of data from the WARD and gain a good sense of your water loss standing

Course 1 Summary:

The AWWA Water Balance defines the components of Non-revenue Water and is the basis for the AWWA Water Audit Method

The Version 6.0 AWWA Free Water Audit Software and companion Compiler Tool have powerful new features

AWWA's performance indicators allow for reliable assessment on Non-revenue Water, and assist in water loss reduction performance tracking and comparisons with other utilities

AWWA's Water Audit Reference Dataset (WARD) provides ranges of performance indicator values from over one thousand North American water utilities and allows water utilities to make comparisons with this data

Course 1
Final Assessment Questions

- *Included separately*

Assessing Non-revenue Water with the AWWA Water Audit – ELXX, 1st Ed

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Course 2 Preview

Accurate Metering of Water Production Flows

This course will present best practices for the management of production flowmeters and the data they produce, including:

- Types of flowmeters
- Flowmeter accuracy testing and replacement
- Flowmeter data and effective data management

Thank you for completing Course 1

AWWA eLearning

Assessing Non-revenue Water with the AWWA Water Audit Method