Colorado Water Loss Initiative

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

CAVANAUGH
Stewardship Through Innovation

E Source

New Learner Workshop

May 25, 2023

COLORADO

Colorado Water
Conservation Board

Department of Natural Resources

Program Management Team

Expert Leadership

Drew Blackwell,
Program Manager

Isabel Szendrey,
Program Manager

Expert Teachers

Tory Wagoner

Reinhard Sturm

Maher Lugo

Larry Lewison

Kevin Burgers

Utility Introductions

Agenda

Water Loss Initiative: Overview & Objectives	AWWA M36 Foundations, Data Sources & Developing the Inputs	Break	AWWA Free Water Audit Software
Group Exercise: Developing the Inputs	Data Validity Grading	Group Exercise: Data Validity Grades	Level 1 Validation
Review	Next Steps	Question & Answer team@coloradowaterloss.org Colorado Wate Loss Initiative	

Water Loss Initiative: Overview & Objectives

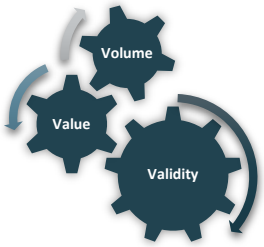
Annual Water Balance

Annual M36 water audit

Apparent & Real Loss volumes

Level 1 validation

baseline



Stage 1

Loss Profiling & Uncertainty

Advanced Validation
- Level 2 Analytics
- Level 3 Field Study
- Margins of Error

Apparent Loss Profile
- Theft
- Meter Inaccuracy
- Data Handling

Real Loss Profile
- Reported Leakage
- Unreported Leakage
- Background Leakage

technical analysis

Stage 2

Cost-Benefit & Targets

Costs of losses
- by subcomponent
- in aggregate
- wholesale & retail

Costs of intervention strategies

Program design

System-specific

economic analysis

Stage 3

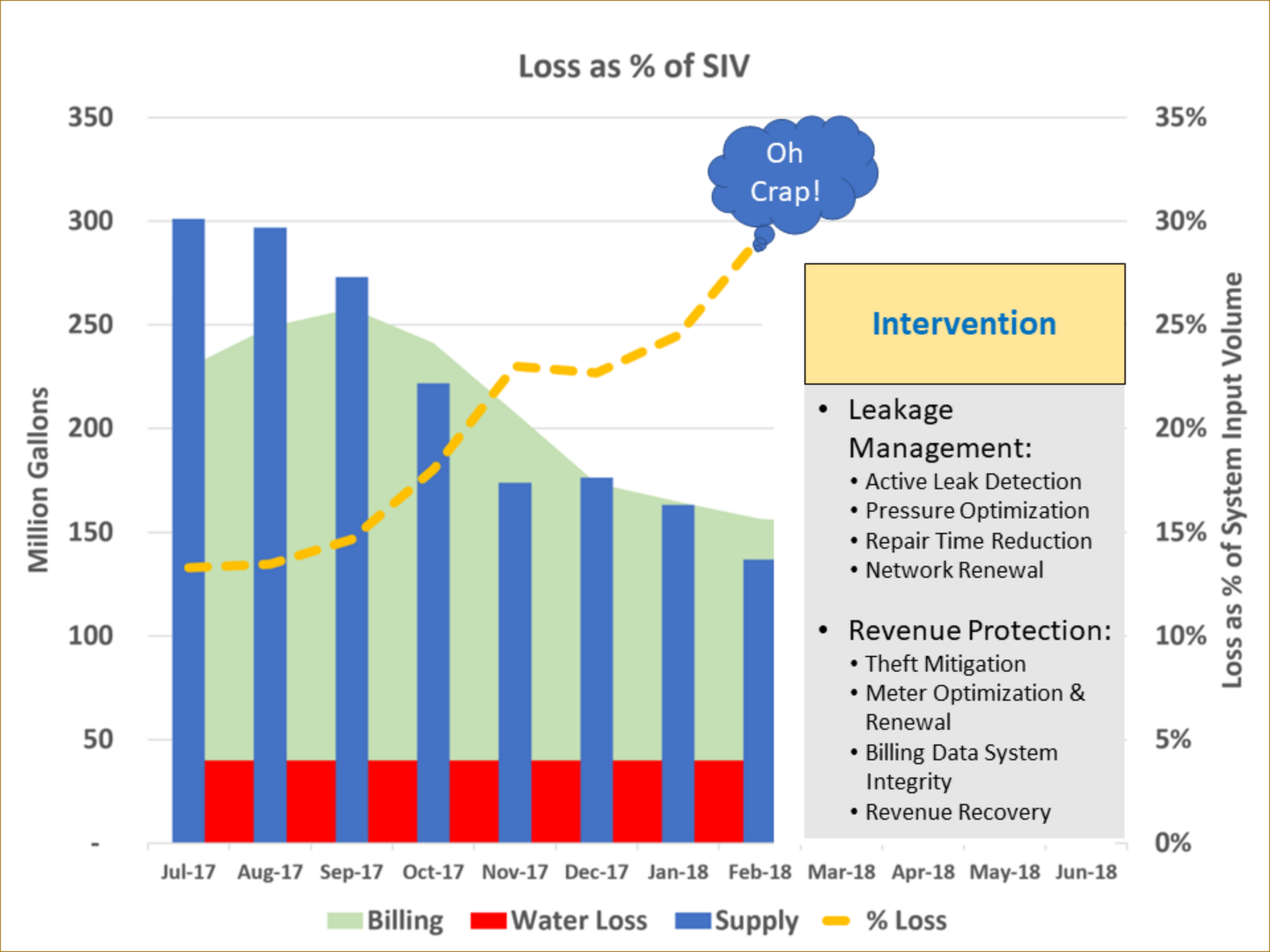
Intervention

Leakage Management:
- Active Leak Detection
- Pressure Optimization
- Repair Time Reduction
- Network Renewal

Revenue Protection:
- Theft Mitigation
- Meter Optimization & Renewal
- Billing Data System Integrity
- Revenue Recovery

cost-effectiveness

Stage 4


Loss as % of SIV
350
300
250
200
150
100
50
-
Million Gallons
35%
30%
25%
20%
15%
10%
5%
0%
Loss as % of System Input Volume
Oh Crap!
Intervention
• Leakage Management:
• Active Leak Detection
• Pressure Optimization
• Repair Time Reduction
• Network Renewal
• Revenue Protection:
• Theft Mitigation
• Meter Optimization & Renewal
• Billing Data System Integrity
• Revenue Recovery
Jul-17
Aug-17
Sep-17
Oct-17
Nov-17
Dec-17
Jan-18
Feb-18
Mar-18
Apr-18
May-18
Jun-18
Billing
Water Loss
Supply
% Loss

AWWA M36 Methodology – State of the Art Water Auditing & Loss Control

American Water Works Association

AWWA adopts IWA standard, abandons Unaccounted For Water

WRF study shows audit validity is a widespread challenge

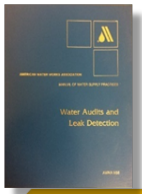
Validation method developed

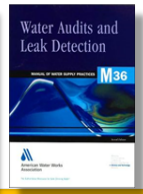
M36 1st Ed.

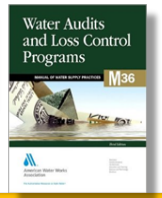
M36 2nd Ed.

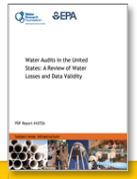
M36 3rd Ed.

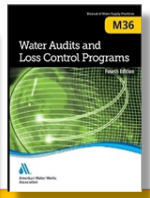
M36 4th Ed.

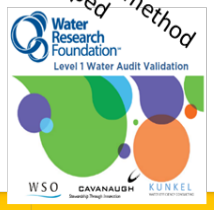












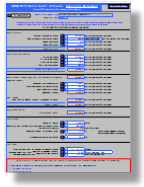
American Water Works Association

Water Research Foundation

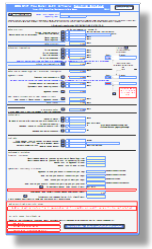
Ongoing Research & Development:
Performance Indicator Task Force
WRF 4695-Effective WLC Planning

1991 | 1999 | 2003 | 2006 | 2009 | 2010 | 2014 | 2015 | 2017 | 2019 | 2020

AWWA Audit Software v1



AWWA Audit Software v4



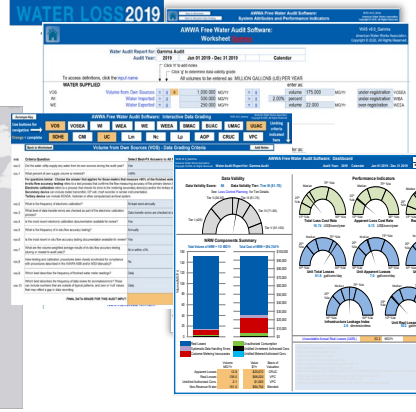
AWWA Audit Software v5

NORTH AMERICAN WATER LOSS 2015
Georgia

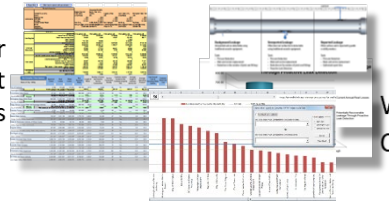
NORTH AMERICAN WATER LOSS 2017
California

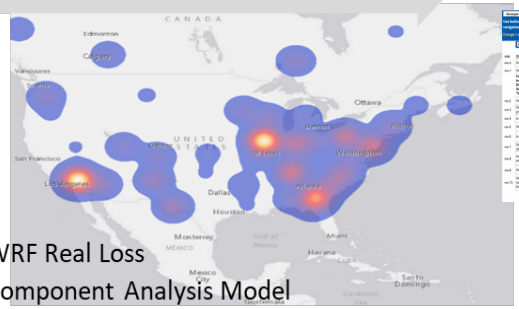
NORTH AMERICAN WATER LOSS 2019

AWWA Audit Software v6



AWWA Compiler developed for large audit sets

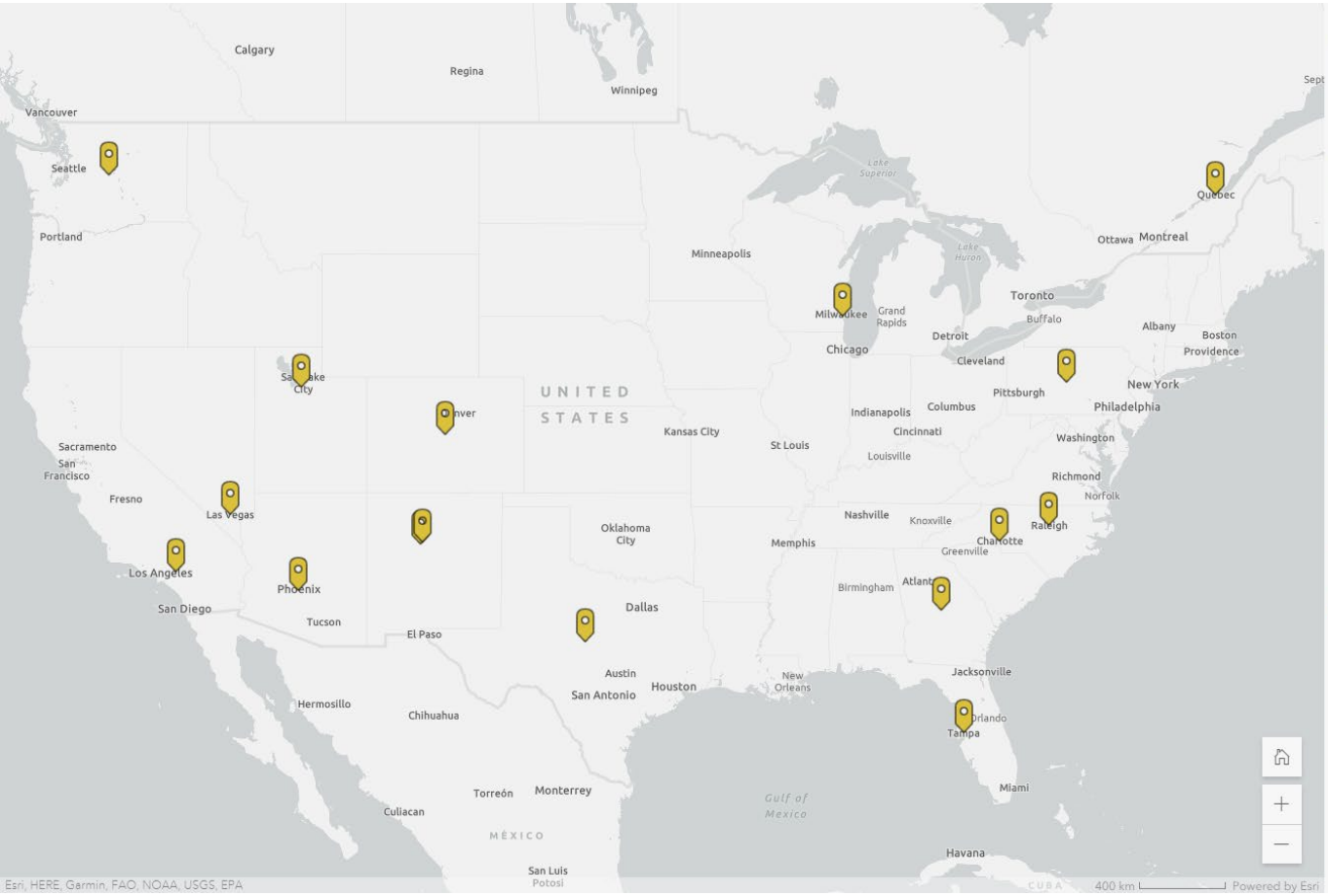




WRF Real Loss Component Analysis Model

Water Loss Training and Technical Assistance Programs in North America

Pilot Studies | Statewide Programs | Certification Programs




Georgia Water Loss Program


Wisconsin M36 Water Loss Auditing


New Mexico Water Loss Control Training Program

California Water Loss Technical Assistance…


Utah Water System Efficiency and Water Loss…

Washington Water Loss Pilot Program

Florida Water Loss Pilot Technical Assistance…

North Carolina Water Loss Program


The Catawba-Wateree Water Loss Program


Arizona Water Loss Pilot Program


Colorado Water Loss Initiative


Quebec's Water Efficiency Strategy

https://arcg.is/1nrHTv0

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

Colorado Water Loss Initiative

NORTH AMERICAN WATER LOSS 2021

AUSTIN, TEXAS | DECEMBER 7-9

Save the Date!

NAWL
NORTH AMERICAN WATER LOSS 2023

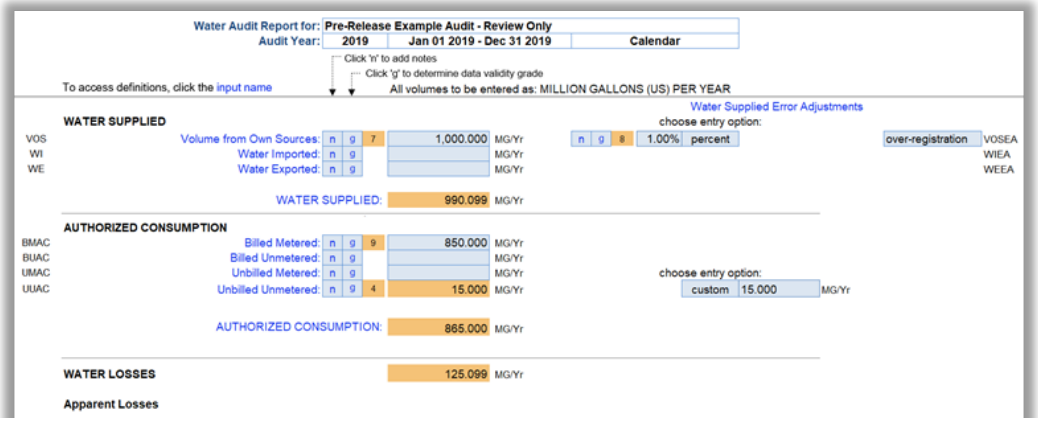
Denver, CO | December 5-7, 2023

Background

- **2010**: HB10-1051 passed
  - Covered entities selling >2,000 Acre Feet per year
  - Requirement for water use and conservation reporting
  - Includes reporting on water loss
- **February 1, 2012**: CWCB adopts Guidelines and reports to legislature regarding the Guidelines.
- **June 30, 2014** : Annual covered entity reporting for the previous calendar year began.
- **2015:** Colorado Water Loss Pilot Program
- **2018-2020:** Colorado Water Loss Initiative – Phase 1
- **2021:** Colorado Water Loss Initiative – Phase 2 launch

Water Loss Program Benefits

- *Training and assistance to implement the AWWA M36 Methodology*
- *Contribute to broader conservation efforts*
- *Provide insight for utility operation & revenue improvement*



Water Audit Report for: Pre-Release Example Audit - Review Only
Audit Year: 2019 | Jan 01 2019 - Dec 31 2019 | Calendar

Click 'n' to add notes
Click 'g' to determine data validity grade

To access definitions, click the input name

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

Water Supplied Error Adjustments

WATER SUPPLIED

choose entry option:

VOS	Volume from Own Sources:	n	g	7	1,000.000	MG/Yr	n g 8	1.00%	percent	over-registration VOSEA
WI	Water Imported:	n	g			MG/Yr				WIEA
WE	Water Exported:	n	g			MG/Yr				WEEA
	WATER SUPPLIED:				990.099	MG/Yr				

AUTHORIZED CONSUMPTION

choose entry option:

BMAC	Billed Metered:	n	g	9	850.000	MG/Yr			
BUAC	Billed Unmetered:	n	g			MG/Yr			
UMAC	Unbilled Metered:	n	g			MG/Yr			
UUAC	Unbilled Unmetered:	n	g	4	15.000	MG/Yr	custom	15.000	MG/Yr
	AUTHORIZED CONSUMPTION:				865.000	MG/Yr			

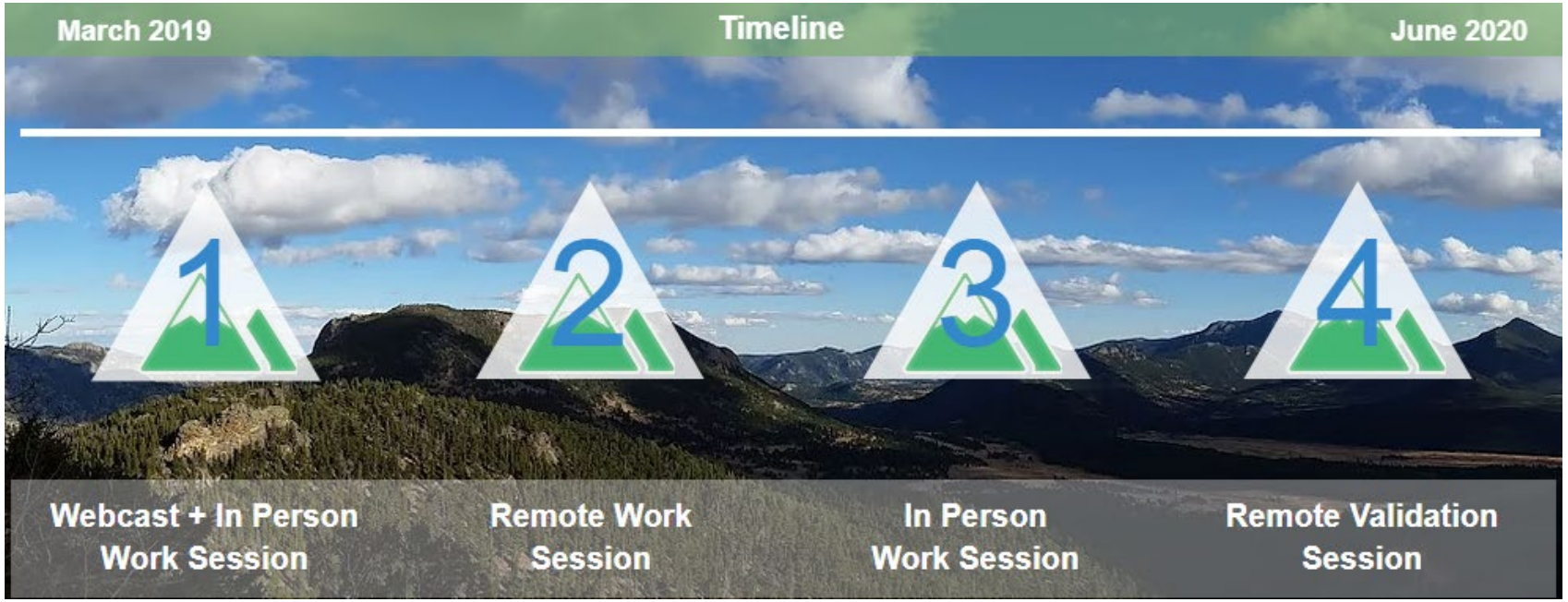
WATER LOSSES 125.099 MG/Yr

Apparent Losses

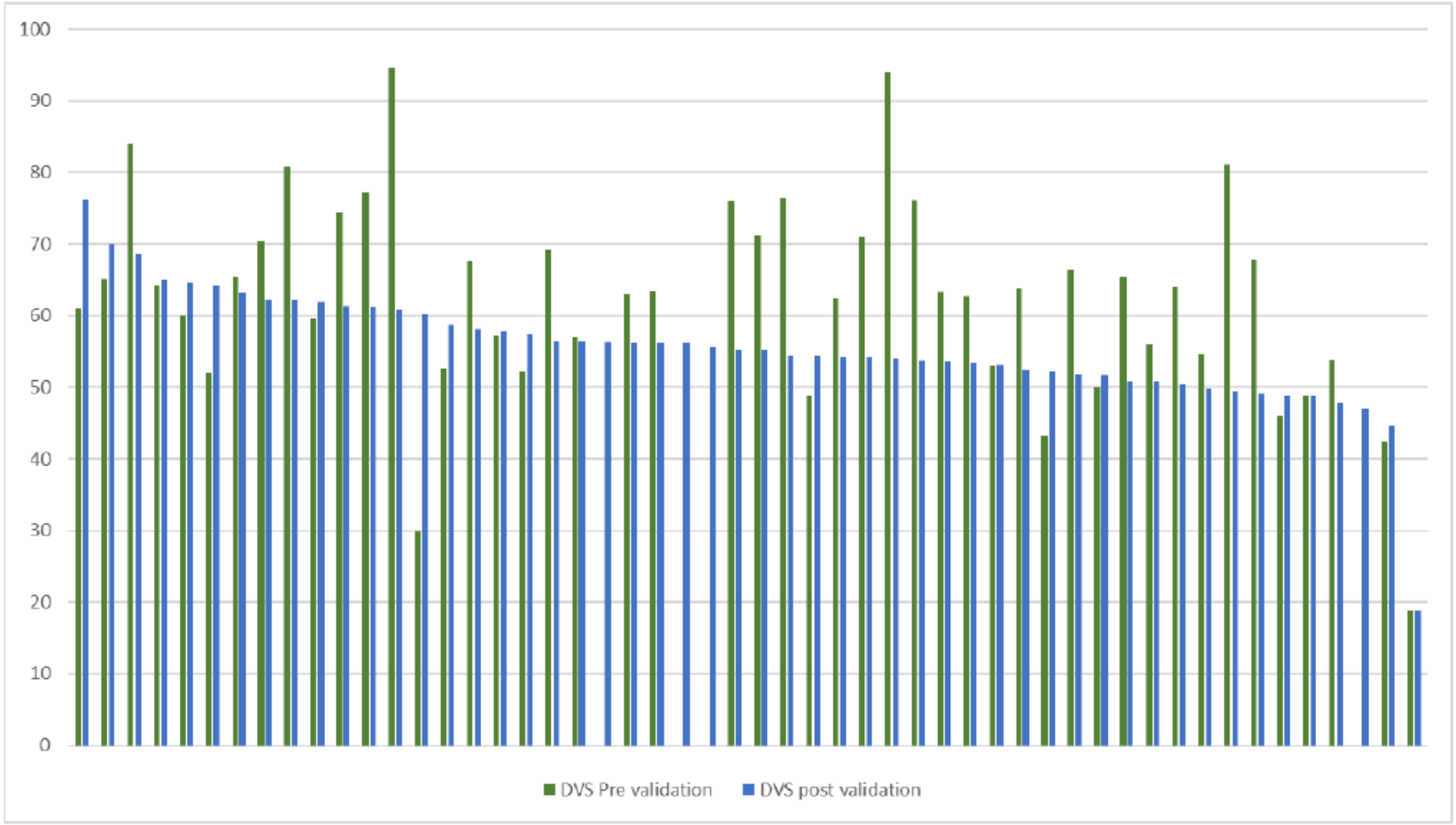
Phase 1 – Program Summary

Goals:

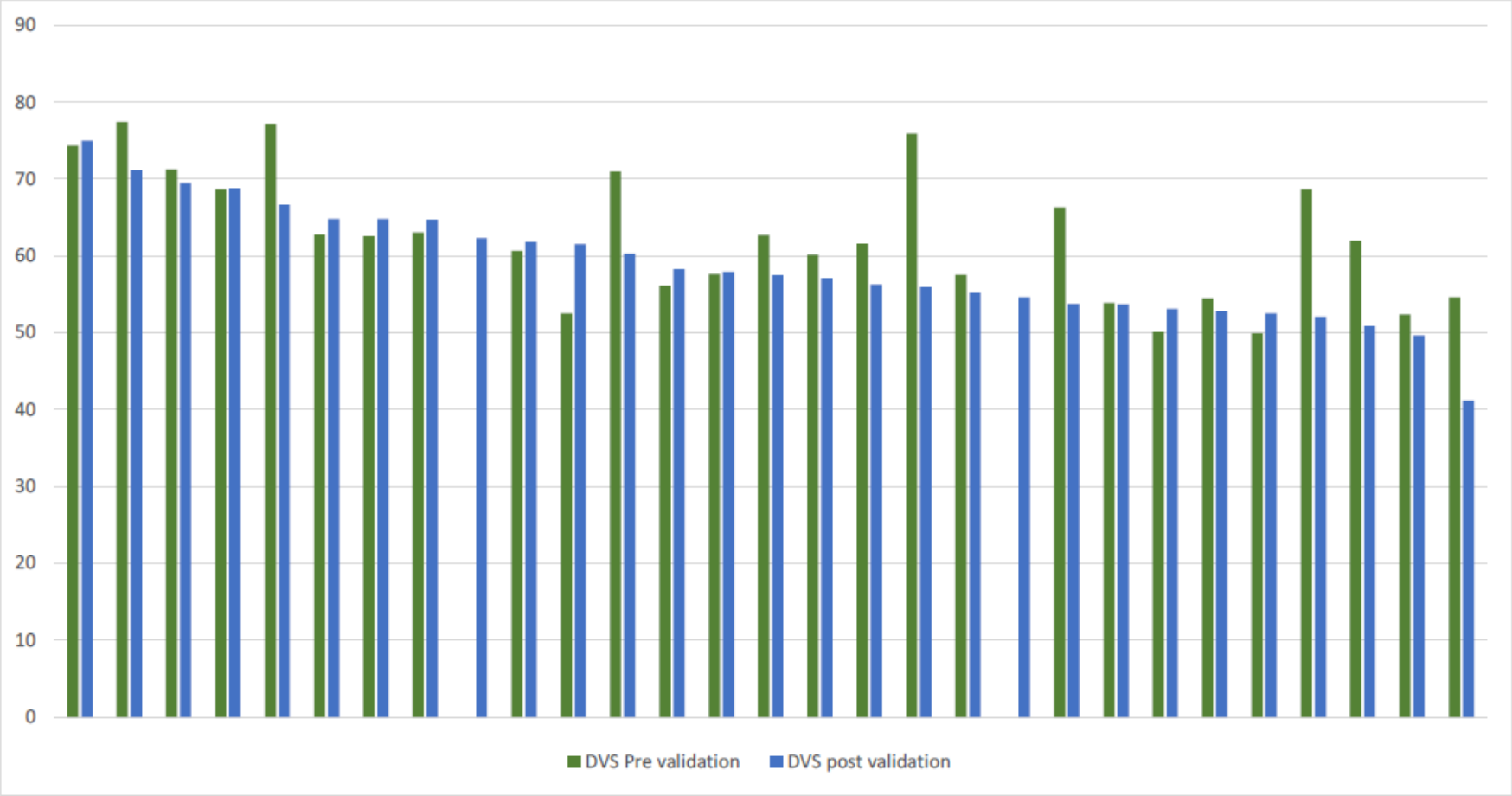
- *Training on AWWA Water Audit Methodology*
- *Level 1 Validation of Water Audits*



Stage 2 - Data Validity Scores – Pre and Post Validation



Stage 4 - Data Validity Scores – Pre and Post Validation



Phase 1 – Program Summary

- Voluntary environment
- Key concepts of AWWA M36 methodology
- Importance of Level 1 Validation
- Not over-burdensome
- Most feel they have the capacity to continue
- Appetite for additional training and technical assistance

Phase 2 - Program Objectives

- Provide a comprehensive program of basic and advanced training in water loss management
- Prioritized technical review for all participants
  - New Learners: Introduction to the AWWA M36 methodology, Free Water Audit Software, and Level 1 Water Audit Validation
  - Advanced Learners: A focus on more advanced techniques and concepts paired with direct technical assistance

Your Water Loss Team

Who should participate from your utility?

Supply & Operations

Customer Metering

Billing & Finance

Management

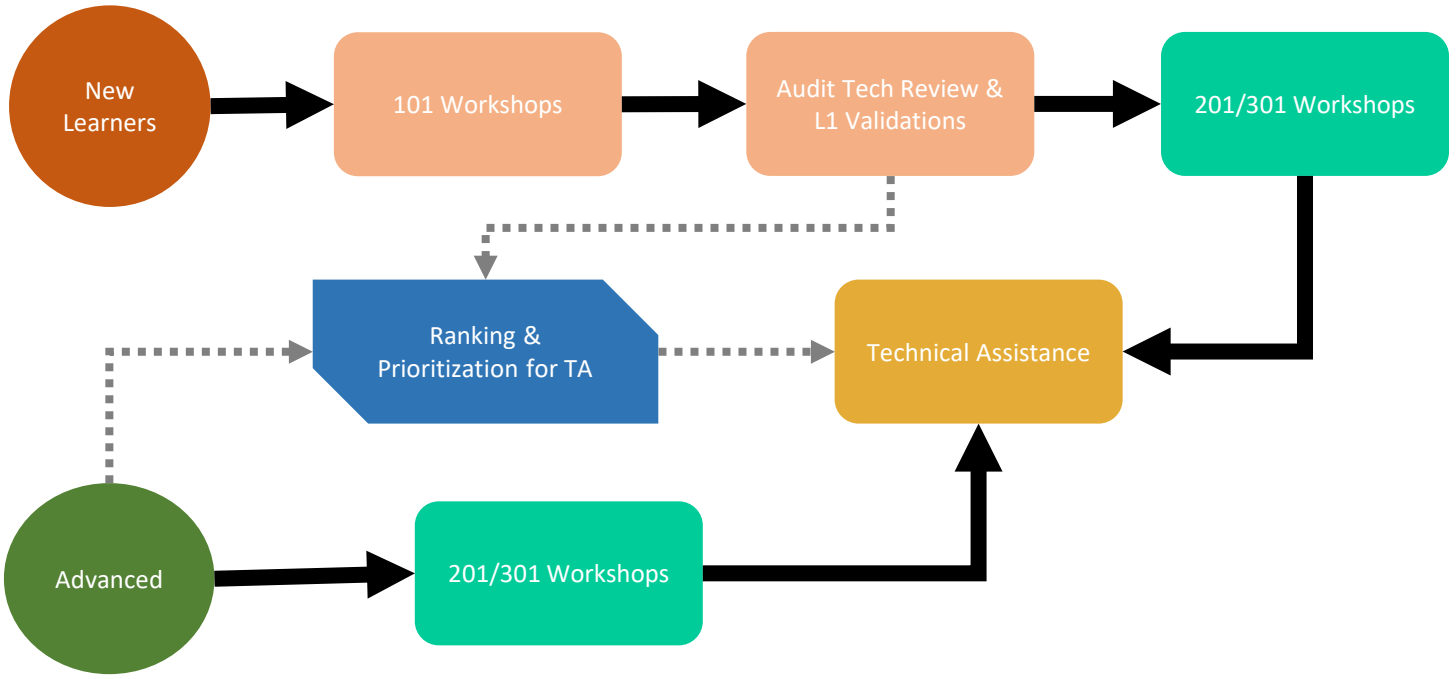
who is responsible for

supplying audit data?

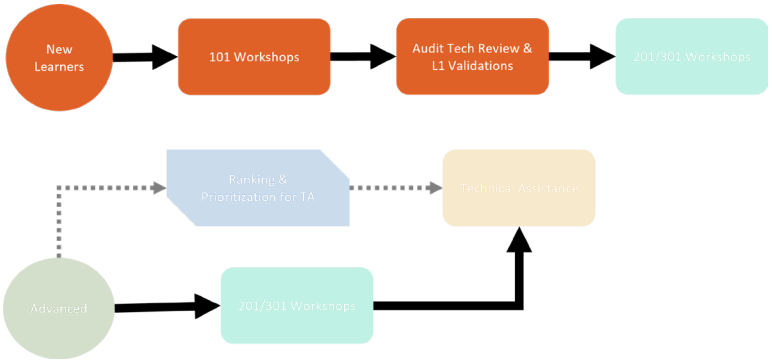
submitting the audit?

coordinating schedules?

Phase 2 Design



Phase 2 – New Learners



Workshop

- AWWA M36 methodology
- AWWA Free Water Audit Software – Ver. 6

Technical Review

- Gather supporting documentation and compile audit
- Technical review to assess readiness for Level 1 Validation session

Level 1 Validation

- Conduct Level 1 Validation
- Document results

Knowledge Check

Which is a possible driver for setting up a water loss program?

A. Environmental
B. Public Relations
C. Regulatory
D. Economic
E. All of the above

AWWA M36 Foundations, Data Sources & Developing the Inputs

AWWA Water Audit :

- What is a water audit?
- What are water audit volumes?

Water Audit

1. Systematically account for known water volumes to estimate volumes of **Water Loss**.

2. Evaluate **data source reliability**.

3. **Communicate** water distribution efficiency.

The Water Balance

1. Account for volumes…

<table>
<tr><td rowspan="6">WATER SUPPLIED</td><td rowspan="4">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="2">UNBILLED AUTHORIZED CONSUMPTION</td><td>UNBILLED METERED CONSUMPTION</td><td rowspan="4">$ $ $

NONREVENUE WATER

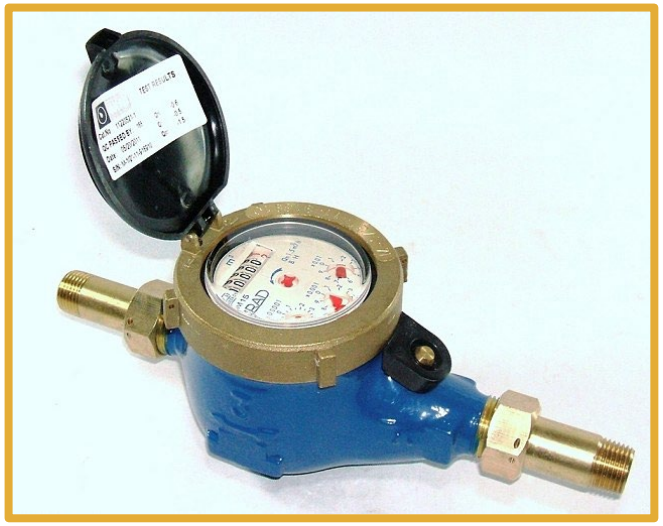
💧</td></tr>
<tr><td>UNBILLED UNMETERED CONSUMPTION</td></tr>
<tr><td rowspan="3">WATER LOSSES</td><td rowspan="2">$ $ $
APPARENT LOSSES
$ $ $</td><td>CUSTOMER METER INACCURACIES</td></tr>
<tr><td>UNAUTHORIZED CONSUMPTION</td></tr>
<tr><td colspan="2">💧 REAL LOSSES 💧</td><td>DATA HANDLING ERRORS</td></tr>
</table>

- *Mass balance – process of elimination*
- *Account for all water*
- *Accuracy matters!*

Water Losses

1. …Estimate volumes of Water Loss!

Apparent Losses

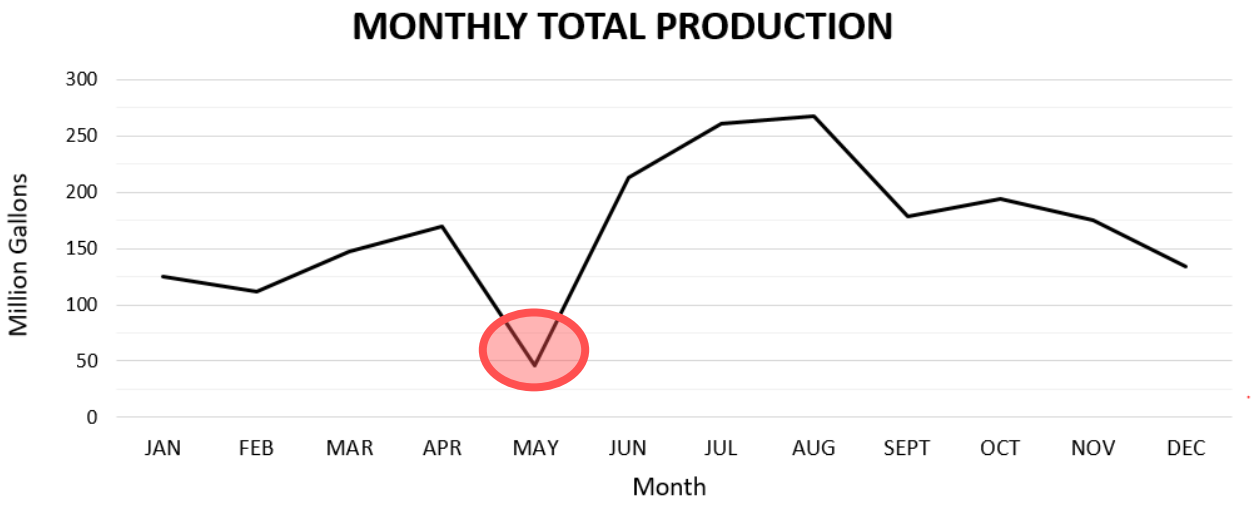


Real Losses

Water Audit

2. Evaluate data reliability

Complete? Consistent? Accurate?



Does the data story make sense?

Water Audit

3. Communicate water distribution efficiency

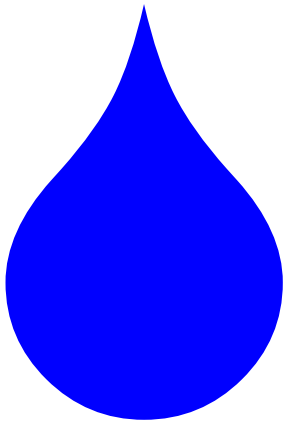
customized performance indicators

financial value of Water Losses

$ $ $

Water Audit

volumes



values

validity

Water Audit Volumes

The big volumes…

Water Supplied

Authorized Consumption

Water Losses

each volume is composed of sub-volumes

Water Supplied

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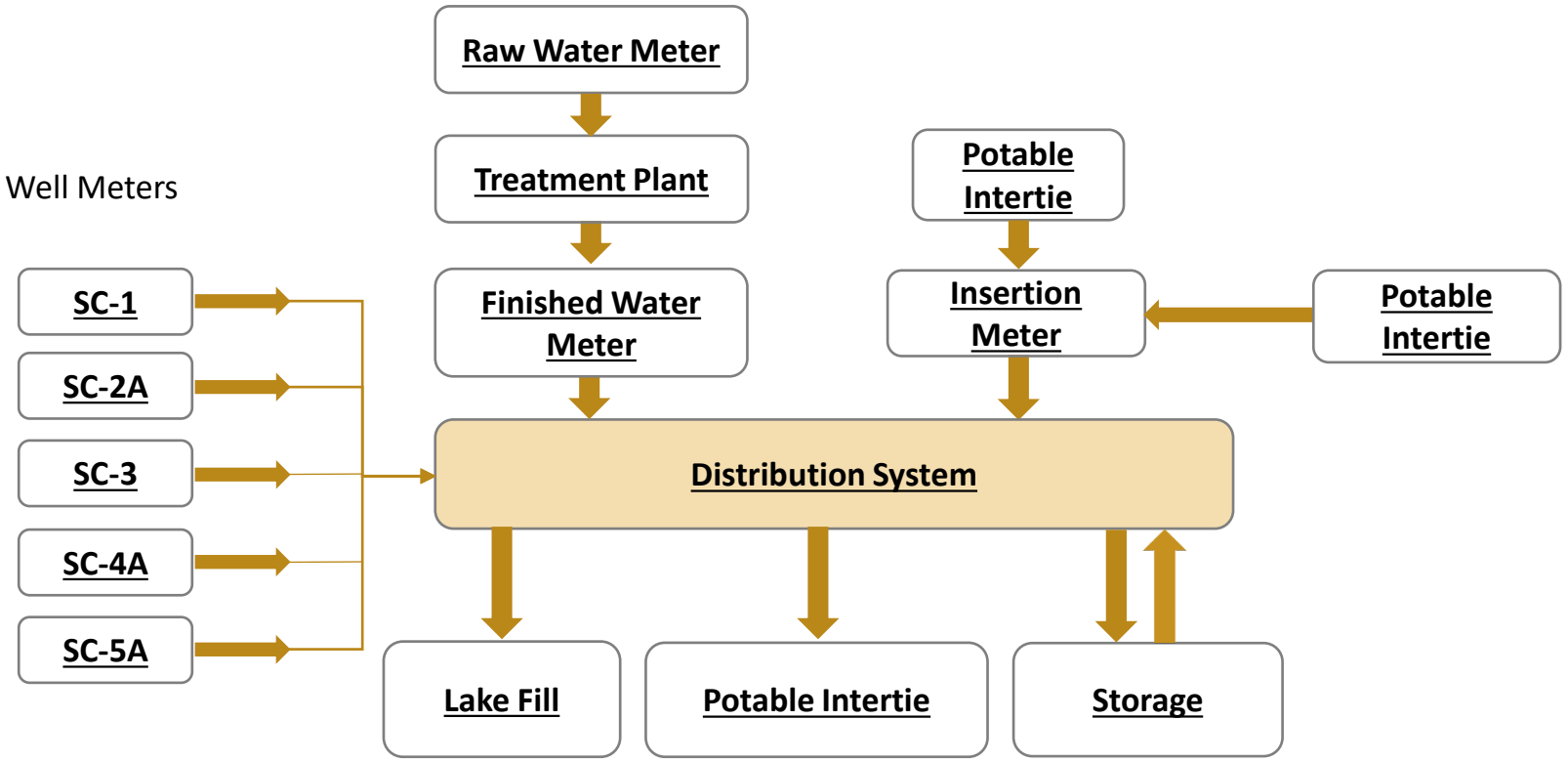
</table>

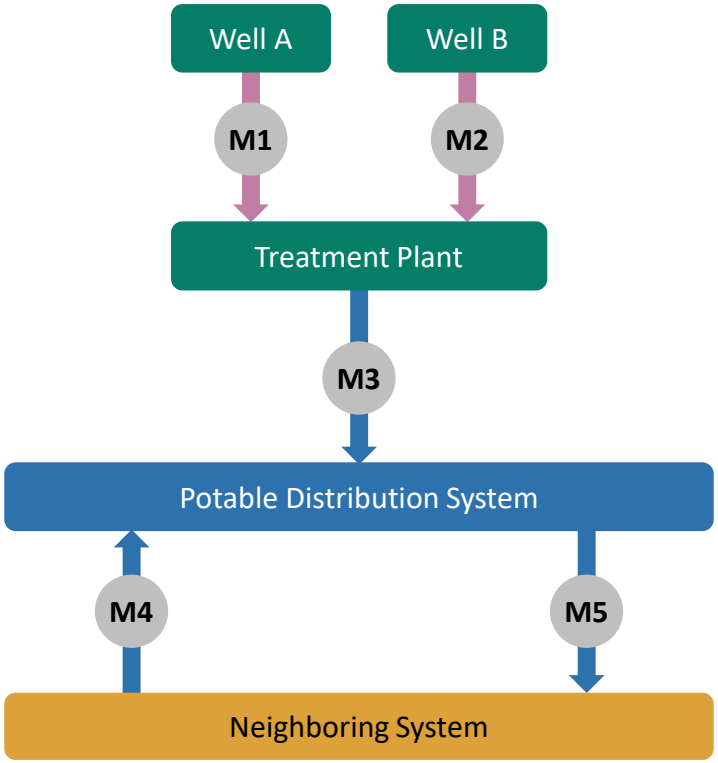
Water Supplied – Audit Boundaries

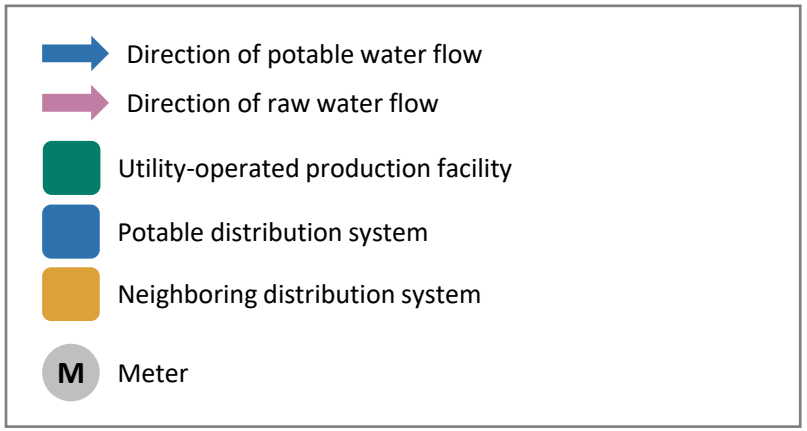


Knowledge Check

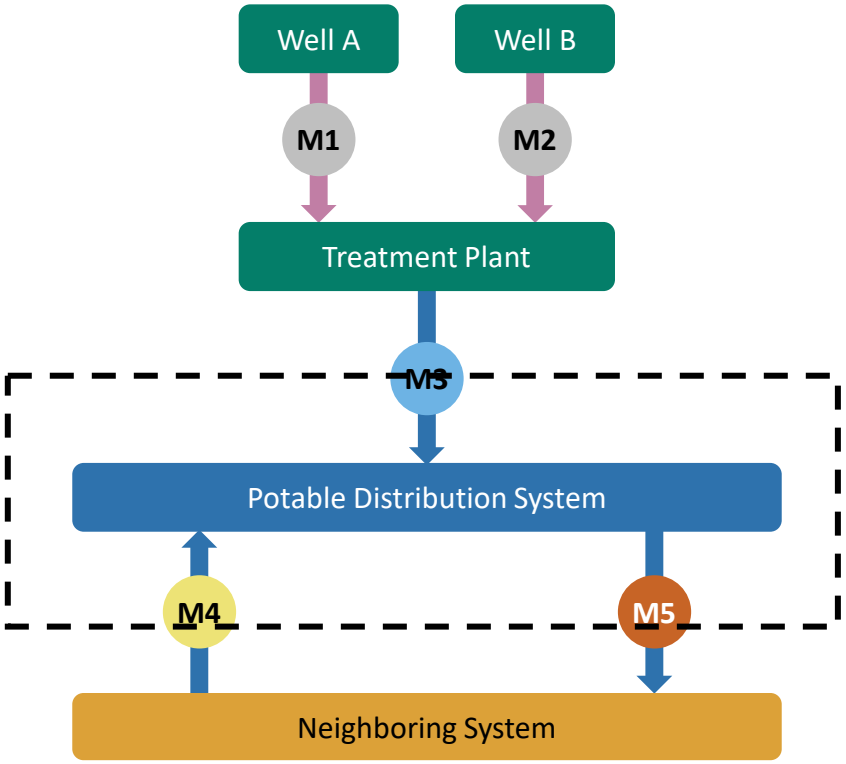
Water Audit Boundary

Water Audit Boundary Exercise





Water Audit Boundary



Direction of potable water flow

Direction of raw water flow

Utility-operated production facility

Potable distribution system

Neighboring distribution system

*Meters that form **example** water audit boundary*

Meter **used** to determine volume from own sources (VOS)

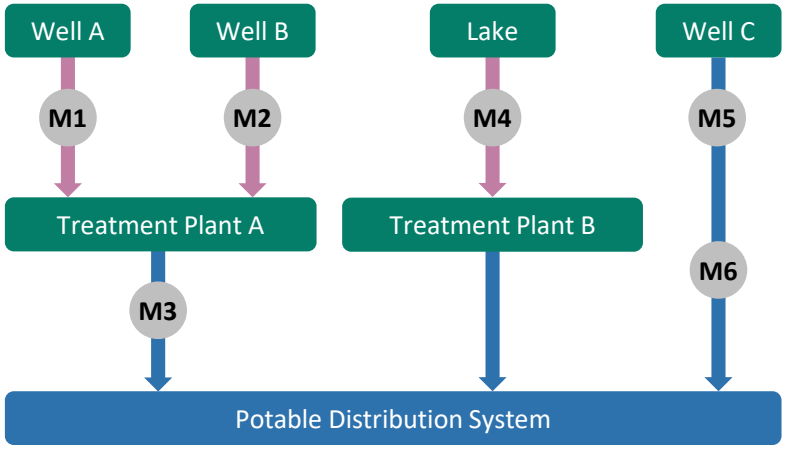
Meter **used** to determine water imported (WI)

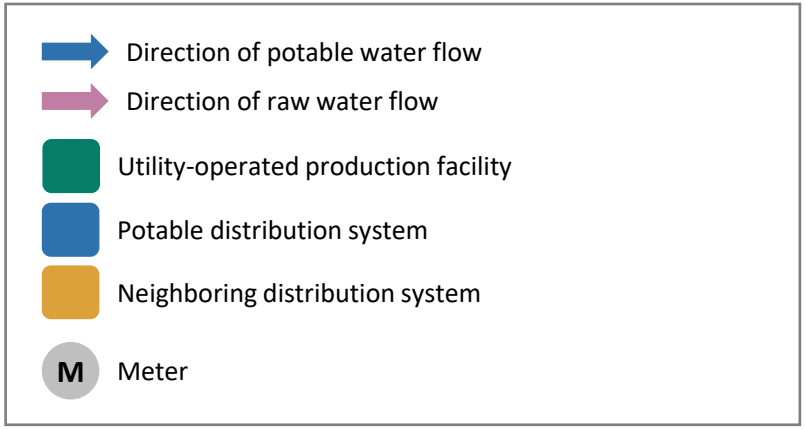
Meter **used** to determine water exported (WE)

*Meters that are not part of **example** water audit boundary*

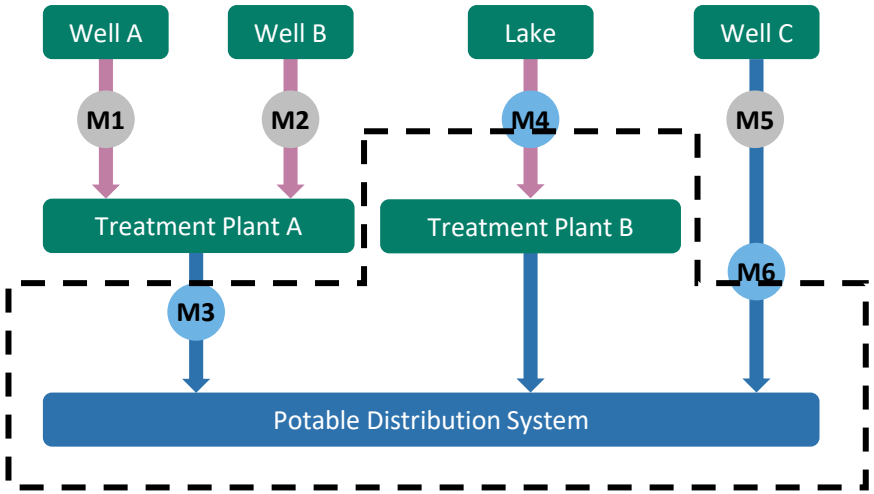
Meter **not used** to determine VOS, WI, or WE

Water Audit Boundary Exercise





Water Audit Boundary



Direction of potable water flow

Direction of raw water flow

Utility-operated production facility

Potable Distribution System

Meter determines volume from own sources (VOS).

Meter **not used** to determine VOS.
This meter **is not** part of an ***example*** water audit boundary.

Water Supplied

[inputs] — [exports]

Volume from Own Sources

Water Imported

Water Exported

captures all the potable water input to the distribution system to serve your customers

Water Supplied

Volume from Own Sources

groundwater
surface water

Which meters?

Where are the meters?

Water Supplied

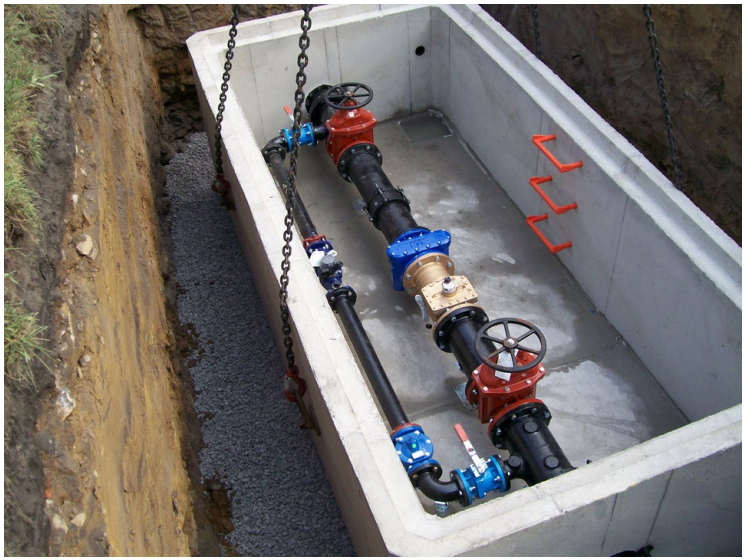
Water Imported

Which meters?

How is Water Imported tracked?

Water Supplied

Water Exported



bulk water sales

supplements to raw/reclaimed systems

Which meters?

How is Water Exported tracked?

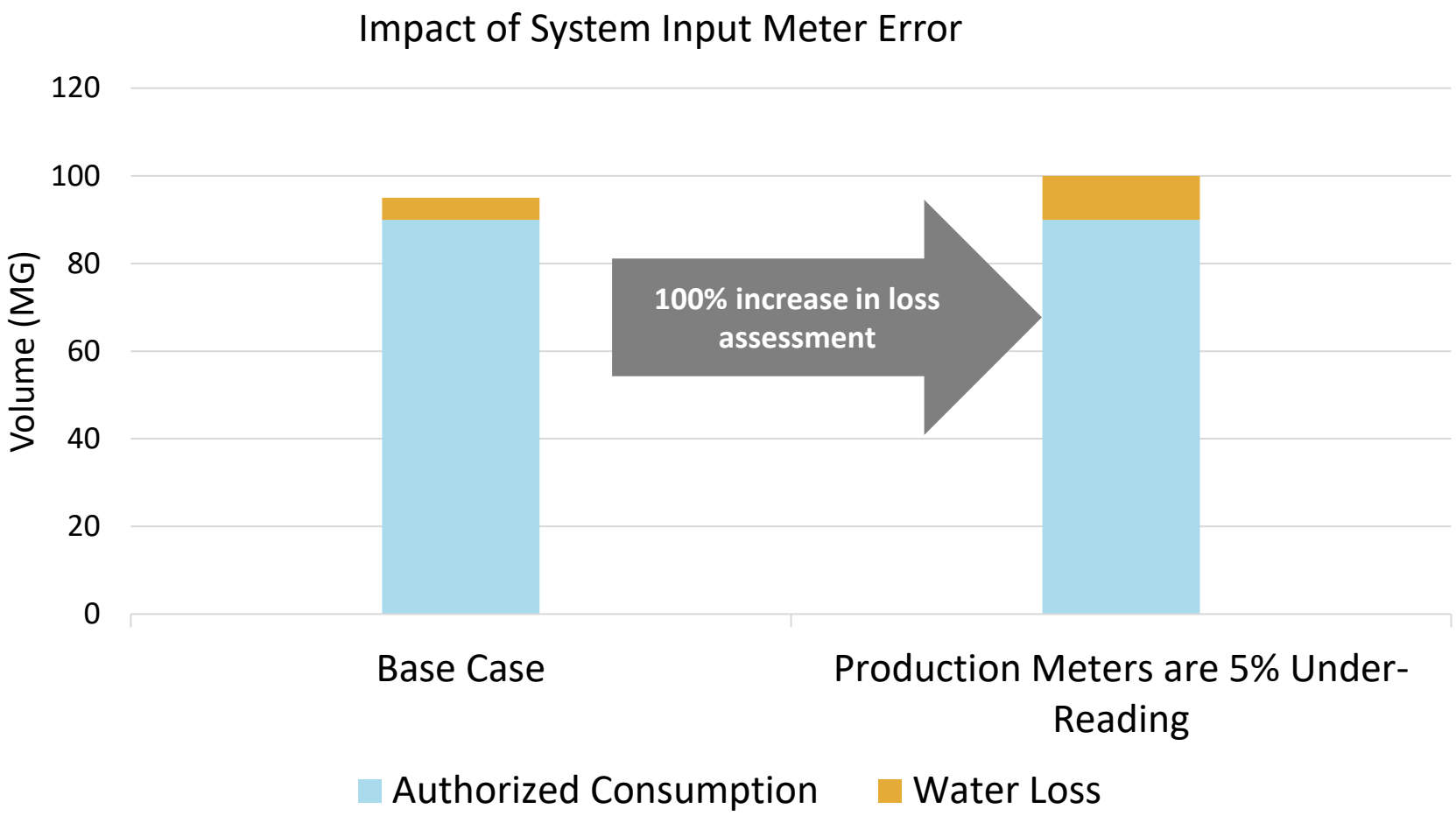
Water Supplied

Master Meter Error Adjustment

How accurate are Water Supplied meters?

electronic calibration
volumetric accuracy testing

Source Meter Testing



Authorized Consumption

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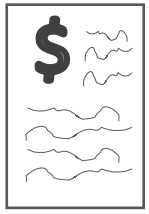
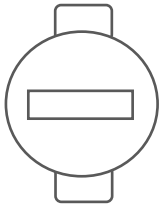
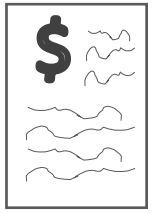
Authorized Consumption

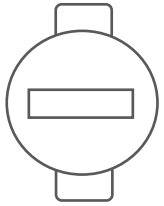




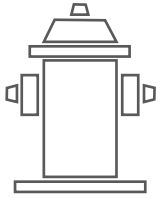
Billed Metered Consumption



Billed Unmetered Consumption



Unbilled Metered Consumption



Unbilled Unmetered Consumption

How much **water is used** for all intended purposes?

How accurate are tracking mechanisms?

Billed Metered Authorized Consumption

<table>
<tr><td rowspan="7">WATER SUPPLOED</td><td rowspan="4">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="2">UNBILLED AUTHORIZED CONSUMPTION</td><td>UNBILLED METERED CONSUMPTION</td></tr>
<tr><td>UNBILLED UNMETERED CONSUMPTION</td></tr>
<tr><td rowspan="3">WATER LOSSES</td><td rowspan="2">APPARENT LOSSES</td><td>CUSTOMER METER INACCURACIES</td><td rowspan="3">NONREVENUE WATER</td></tr>
<tr><td>UNAUTHORIZED CONSUMPTION</td></tr>
<tr><td>DATA HANDLING ERRORS</td></tr>
<tr><td colspan="2">REAL LOSSES</td></tr>
</table>

Billed Metered Authorized Consumption

A lot of data

Duplicates

Missing Data

Negative Reads

Zero Reads

Adjustments

Outliers

One summary number

Other Authorized Consumption

<table>
<tr><td rowspan="8">SYSTEM INPUT VOLUME</td><td rowspan="4">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="2">UNBILLED AUTHORIZED CONSUMPTION</td><td>UNBILLED METERED CONSUMPTION</td><td rowspan="5">NONREVENUE WATER</td></tr>
<tr><td>UNBILLED UNMETERED CONSUMPTION</td></tr>
<tr><td rowspan="4">WATER LOSSES</td><td rowspan="3">APPARENT LOSSES</td><td>CUSTOMER METER INACCURACIES</td></tr>
<tr><td>UNAUTHORIZED CONSUMPTION</td></tr>
<tr><td>DATA HANDLING ERRORS</td></tr>
<tr><td colspan="2">REAL LOSSES</td></tr>
</table>

Other Authorized Consumption

Billed Unmetered

Unbilled Metered

Unbilled Unmetered

District use?

City use?

Special customers?

Exemptions?

Now we know Water Losses!

<table>
<tr><td rowspan="6">WATER SUPPLIED</td><td rowspan="4">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="2">UNBILLED AUTHORIZED CONSUMPTION</td><td>UNBILLED METERED CONSUMPTION</td><td rowspan="2"></td></tr>
<tr><td>UNBILLED UNMETERED CONSUMPTION</td></tr>
<tr><td rowspan="4">WATER LOSSES</td><td rowspan="3">APPARENT LOSSES</td><td>CUSTOMER METER INACCURACIES</td><td rowspan="4">NONREVENUE WATER</td></tr>
<tr><td>UNAUTHORIZED CONSUMPTION</td></tr>
<tr><td>DATA HANDLING ERRORS</td></tr>
<tr><td colspan="2">REAL LOSSES</td></tr>
</table>

Water Losses

[Water Supplied] — [Authorized Consumption] =

Water Losses

Real Losses Apparent Losses

Apparent Losses

<table>
<tr><td rowspan="6">WATER SUPPLIED</td><td rowspan="4">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="2">UNBILLED AUTHORIZED CONSUMPTION</td><td>UNBILLED METERED CONSUMPTION</td><td rowspan="4">NONREVENUE WATER</td></tr>
<tr><td>UNBILLED UNMETERED CONSUMPTION</td></tr>
<tr><td rowspan="3">WATER LOSSES</td><td rowspan="3">APPARENT LOSSES</td><td>CUSTOMER METER INACCURACIES</td></tr>
<tr><td>UNAUTHORIZED CONSUMPTION</td></tr>
<tr><td>DATA HANDLING ERRORS</td></tr>
<tr><td colspan="3">REAL LOSSES</td></tr>
</table>

Apparent Losses

water volume that reaches an end user

but is not registered or properly tracked

(and so you're not paid)

Apparent Losses

often referred to as "paper losses"

---

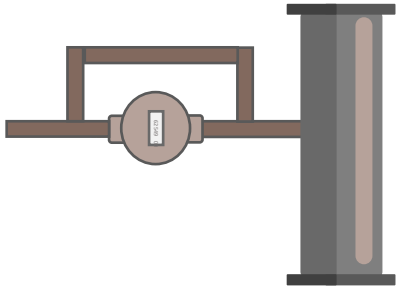
reducing Apparent Losses ***increases revenue***

but creates ***no new water***

$ $ $

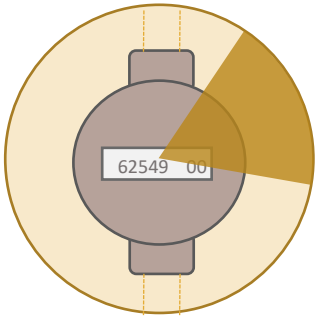
Apparent Loss – Categories

How much water is delivered but not registered (or paid for)?



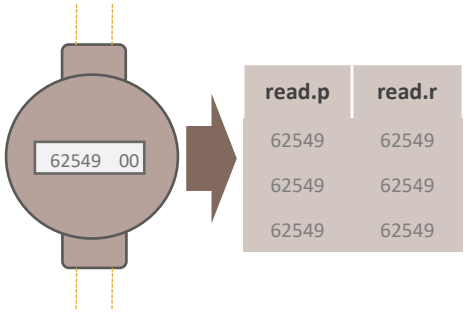
Unauthorized Consumption

Theft!



Metering Inaccuracy

Customer meter under registration

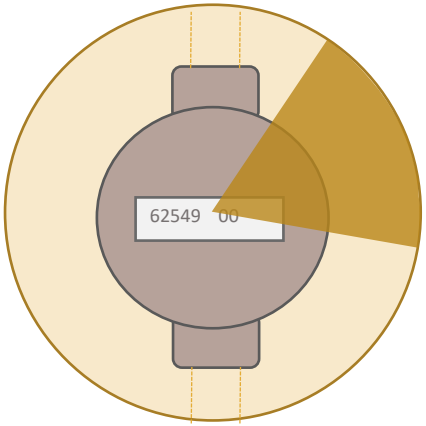


Data Handling Errors

Reporting or other clerical errors during the handling of meter reading data

Apparent Loss – Value

90% Customer Meter Accuracy

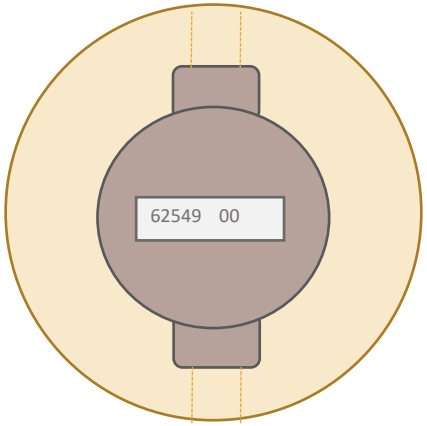


Service Charge: $20

Volume of Use: 9 CCF

Variable Charge: $3.00 x 9 = **$27.00**

100% Customer Meter Accuracy



Service Charge: $20

Volume of Use: 10 CCF

Variable Charge: $3.00 x 10 = **$30.00**

Real Losses

<table>
<tr><td rowspan="8">WATER SUPPLIED</td><td rowspan="5">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>
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<tr><td>DATA HANDLING ERRORS</td></tr>
<tr><td colspan="2">REAL LOSSES</td></tr>
</table>

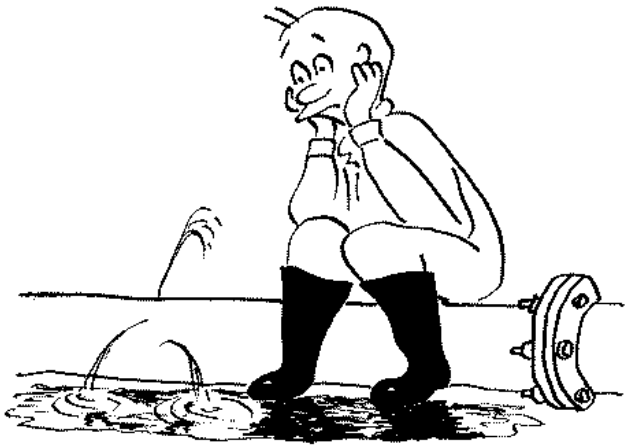
Real Losses

often referred to as "physical losses"

leaks

seeps

breaks



Real Losses

reducing Real Losses ***creates an additional resource***

can reduce operating costs

can defer capital expenditure

System Data

Infrastructure information

- Length of Mains (includes hydrants laterals)
- Count of service connections (active and inactive)

Operating Pressure

used to calculate a technical minimum volume of leakage

Cost Data

Total Annual Operating Cost

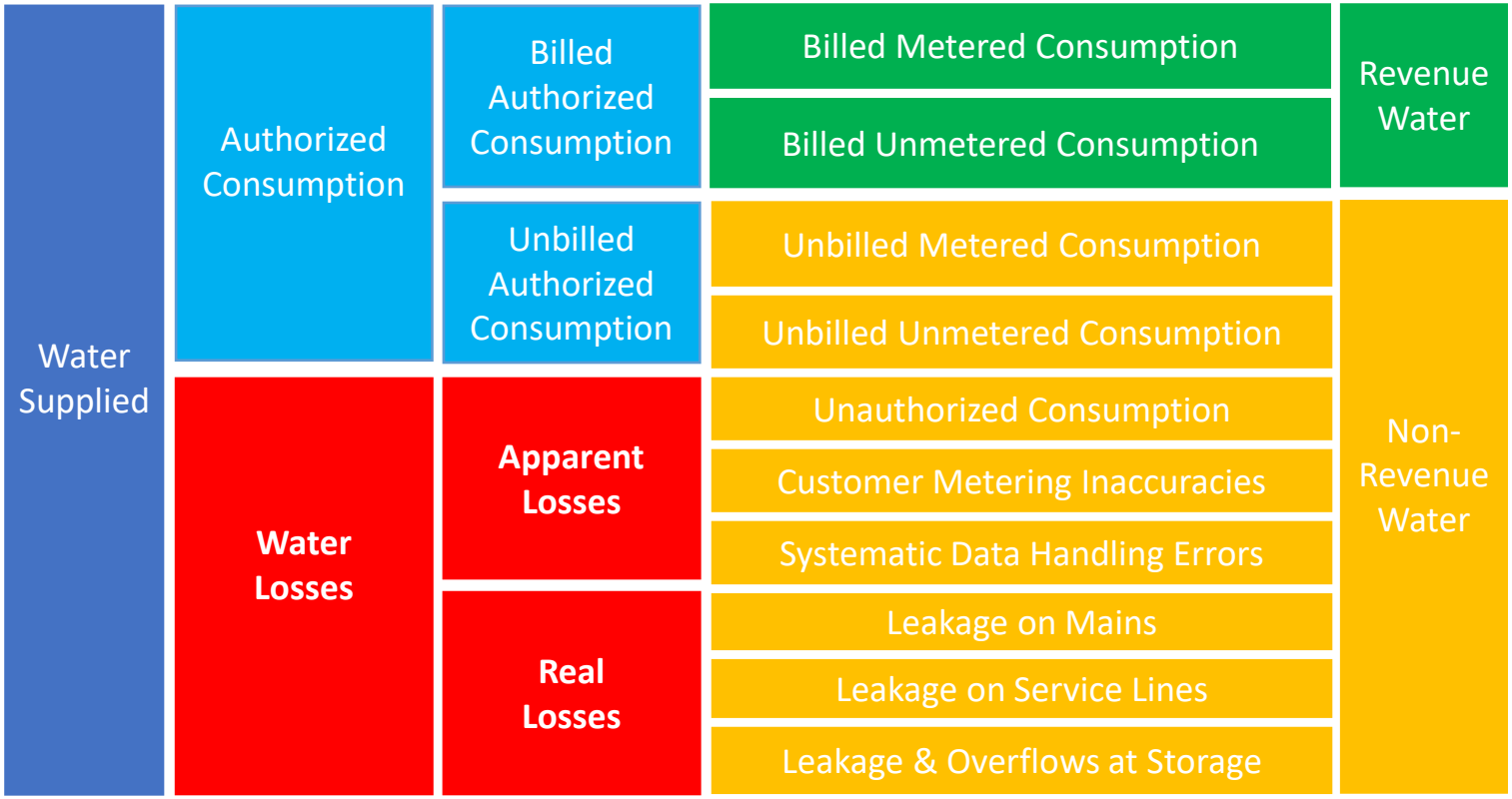
How much are Apparent Losses worth?

Customer Retail Unit Cost

How much are Real Losses worth?

Variable Production Cost

Let's review…

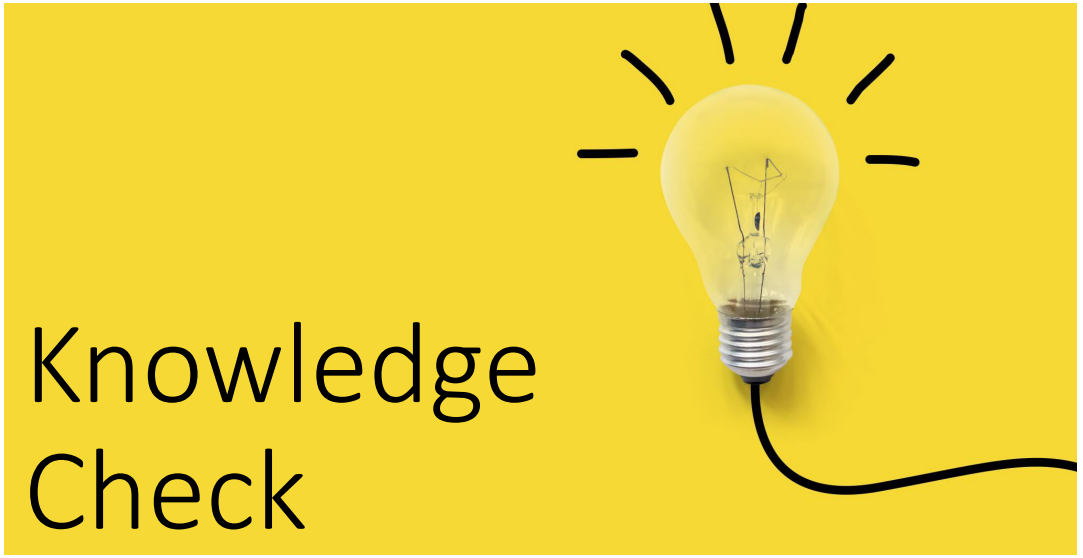

Water Supplied
Authorized Consumption
Water Losses
Billed Authorized Consumption
Unbilled Authorized Consumption
Apparent Losses
Real Losses
Billed Metered Consumption
Billed Unmetered Consumption
Unbilled Metered Consumption
Unbilled Unmetered Consumption
Unauthorized Consumption
Customer Metering Inaccuracies
Systematic Data Handling Errors
Leakage on Mains
Leakage on Service Lines
Leakage & Overflows at Storage
Revenue Water
Non-Revenue Water

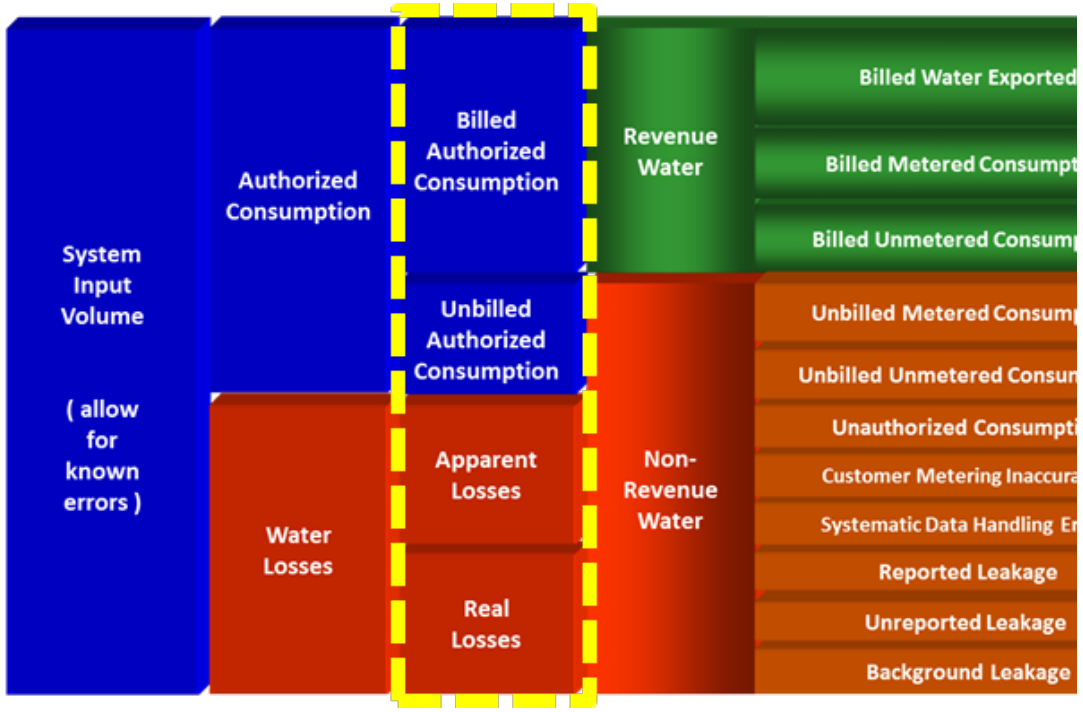
Knowledge Check

Another term for physical leaks in a system is _____?

A. Water theft
B. Billed Metered Authorized Consumption
C. Real Loss
D. Flushing
E. Water Loss

- District facility use
- Tank overflow
- AMR Device transmission failure
- Well water lubrication
- Firefighting
- Main breaks
- Flat-rate condominiums
- Parks department irrigation
- Single-family indoor use
- Under-registered customer meters





Break

AWWA Free Water Audit Software

AWWA M36 Methodology – Evolution of the Water Audit Software

AWWA adopts IWA standard, abandons Unaccounted For Water

WRF study shows audit validity is a widespread challenge

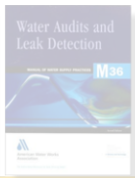
Validation method developed

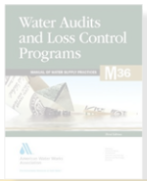
M36 1st Ed.

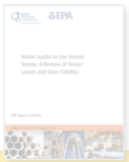
M36 2nd Ed.

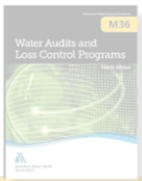
M36 3rd Ed.

M36 4th Ed.









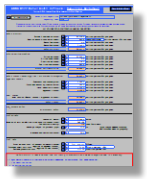
American Water Works Association

Water Research Foundation

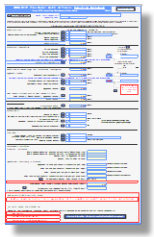
Ongoing Research & Development:
Performance Indicator Task Force
WRF 4695-Effective WLC Planning

1991 | 1999 | 2003 | 2006 | 2009 | 2010 | 2014 | 2015 | 2017 | 2019 | 2020

AWWA Audit Software v1



AWWA Audit Software v4



AWWA Audit Software v5

NORTH AMERICAN WATER LOSS 2015

Georgia

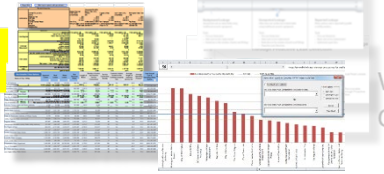
NORTH AMERICAN WATER LOSS 2017

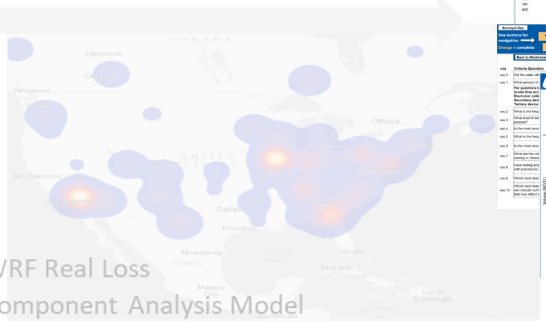
California

NORTH AMERICAN WATER LOSS 2019

AWWA Audit Software v6

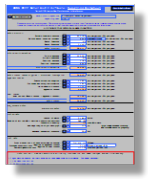
AWWA Compiler developed for large audit sets





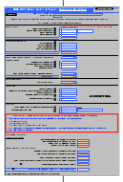
WRF Real Loss Component Analysis Model

FWAS v1
(200)



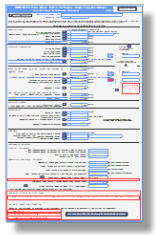
MG volumes only
Data grading:
either ‘measured’
or ‘estimated’

FWAS v2 – v3



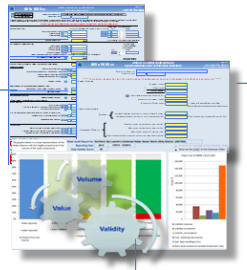
Megaliters added
Two financial performance indicators added (cost of real and apparent losses)
Acre-ft added
Example audits included
Two default values
Data checks / instant feedback added

FWAS v4
(2,000)



Data grading matrix (1-10)
Service connection diagram
French language version available

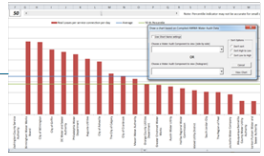
FWAS v5
(13,000)



Separate data input/output tabs
Dashboard
Volume weighted data grading
Comments page
Meter error adjustment for all water supplied components

FWAS v6

AWWA Compiler developed for large audit sets



SUMMARY OF MAJOR V6 IMPROVEMENTS

- Interactive Data Grading to improve consistency, objectivity, transparency in data grade assignment for each input
- Blank sheet for user calculations / extras
- Fighterjet Dashboard
- KPIs updated per AWWA 2020 Position
- KPIs shown on gauge against industry ranges

AWWA Free Water Audit Software – Instructions Worksheet

AWWA Free Water Audit Software v6.0

FWAS v6.0

This spreadsheet-based water audit tool is designed to help quantify and track water losses associated with water distribution systems and identify areas for improved efficiency and cost recovery. It provides a "top-down" summary water audit format and is not meant to take the place of a full-scale, comprehensive water audit format. Auditors are strongly encouraged to refer to the most current edition of AWWA M36 Manual for Water Audits for detailed guidance on the water auditing process and targeting loss reduction levels. This tool contains several separate worksheets. Sheets can be accessed using the tabs at the bottom of the screen, or by clicking the TOC links below.

Table of Contents (TOC)

AWWA Web Resources for Water Loss Control

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

Items referenced in the Free Water Audit Software v6.0 on the web:

- Data Grading Matrix v6.0
- Example Water Audit v6.0
- Water Audit Compiler v6.0
- AWWA Reports on Performance Indicators
- M36 Manual

Enter Basic Information

Name of Utility:	County Water Utility
Name of Contact Person:	John Smith, Manager
Email:	
Telephone | Ext.:	
City/Town/Municipality:	Anytown
State / Province:	
Country:	USA
Audit Preparation Date:	Nov 02 2022
Audit Year:	2021
Audit Year Label:	Calendar (Fiscal, Calendar, etc)
Audit Period Start Date:	Jan 01 2021
Audit Period End Date:	Dec 31 2021
Volume Reporting Units:	Million gallons (US)
Water System Structure:	Retail
Water Type:	Potable Water
System ID Number:	
Validator Name/ID:	
Validator Email:	
Estimated Total Population Served by Water Utility:	

Key of Input Acronyms

In order of appearance in the Worksheet

VOS	Volume from Own Sources
VOSEA	VOS Error Adjustment
WI	Water Imported
WIEA	WI Error Adjustment
WE	Water Exported
WEEA	WE Error Adjustment
BMAC	Billed Metered Authorized Consumption
BUAC	Billed Unmetered Authorized Consumption
UMAC	Unbilled Metered Authorized Consumption
UUAC	Unbilled Unmetered Authorized Consumption
SDHE	Systematic Data Handling Errors
CMI	Customer Metering Inaccuracies
UC	Unauthorized Consumption
Lm	Length of mains
Nc	Number of service connections
Lp	Average length of (private) customer service line
AOP	Average Operating Pressure
CRUC	Customer Retail Unit Charge
VPC	Variable Production Cost

Color Key User input | Calculated | Optional default

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

Guidance for the Interactive Data Grading

Use acronym buttons in IDG header to navigate among inputs. Acronym Key above. White = needs answers, orange = complete, clear = not required. Example below.

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

After clicking an acronym button, answer all visible questions in the order they're presented, choosing best-fit answer

Grade will populate when all visible questions are complete for an input: 7

The limiting criteria will be labeled along the right. If only 1 limiting criterion is shown, improving on that criterion will achieve a higher data grade. If multiple limiting criteria are shown, improving on *each* limiting criterion is necessary to achieve a higher data grade. A complete inventory of data grading criteria is available in the Data Grading Matrix v6.0 (see web resources)

Limiting

If you have questions or comments regarding this software please contact us at: wlc@awwa.org

AWWA Free Water Audit Software Worksheet

Water Audit Report for: **Pre-Release Example Audit - Review Only**
Audit Year: **2019** | **Jan 01 2019 - Dec 31 2019** | **Calendar**

Click 'n' to add notes
Click 'g' to determine data validity grade

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	1,000.000	MG/Yr	n g 8	1.00%	percent	over-registration	VOSEA
WI	Water Imported:	n g		MG/Yr					WIEA
WE	Water Exported:	n g		MG/Yr					WEEA
	WATER SUPPLIED:		990.099	MG/Yr					

AUTHORIZED CONSUMPTION

BMAC	Billed Metered:	n g 9	850.000	MG/Yr	
BUAC	Billed Unmetered:	n g		MG/Yr	
UMAC	Unbilled Metered:	n g		MG/Yr	choose entry option:
UUAC	Unbilled Unmetered:	n g 4	15.000	MG/Yr	custom 15.000 MG/Yr
	AUTHORIZED CONSUMPTION:		865.000	MG/Yr	

WATER LOSSES 125.099 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	2.125	MG/Yr	0.25%	default	
CMI	Customer Metering Inaccuracies:	n g 1	8.586	MG/Yr	1.00%	percent	under-registration
UC	Unauthorized Consumption:	n g 3	2.125	MG/Yr	0.25%	default	

Default option selected for Unauthorized Consumption, with automatic data grading of 3

Apparent Losses: 12.836 MG/Yr

Real Losses

Real Losses: 112.263 MG/Yr

WATER LOSSES: 125.099 MG/Yr

NON-REVENUE WATER

NON-REVENUE WATER: 140.099 MG/Yr

SYSTEM DATA

Lm	Length of mains:	n g 1	200.0	miles	(including fire hydrant lead lengths)
Nc	Number of service connections:	n g 5	5,000		(active *and* inactive)
	Service connection density:		25	conn./mile main	

Are customer meters typically located at the curbstop/property: Yes

Lp		n g 10		

Average length of customer service line has been set to zero and a data grading of 10 has been applied

AOP	Average Operating Pressure:	n g 3	50.0	psi

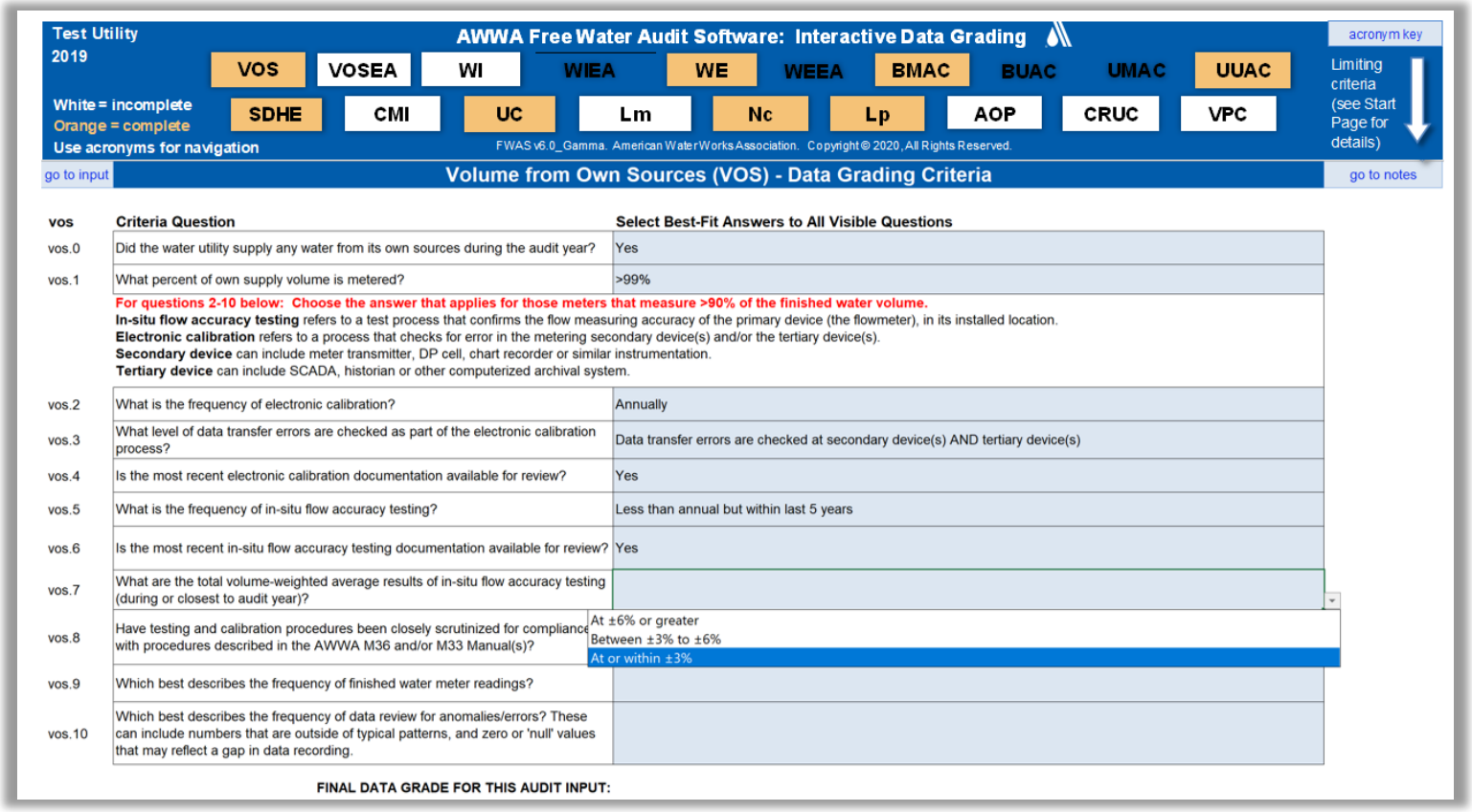
COST DATA

CRUC	Customer Retail Unit Charge:	n g 7	$2.00	$/1000 gallons (US)
VPC	Variable Production Cost:	n g 3	$500.00	$/Million gallons

Total Annual Operating Cost: $2,500,000 $/yr (optional input)

AWWA Free Water Audit Software - Data Grading

- Components are assigned a Grading from 1-10 based upon the validity of the source data and operational practices
- Interactive Data Grading Matrix worksheet gives criteria for grading components according to utility operations and practices
- Grading criteria is a ***process-based*** approach



Test Utility
2019

White = incomplete
Orange = complete
Use acronyms for navigation

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
Limiting criteria (see Start Page for details)

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go to input

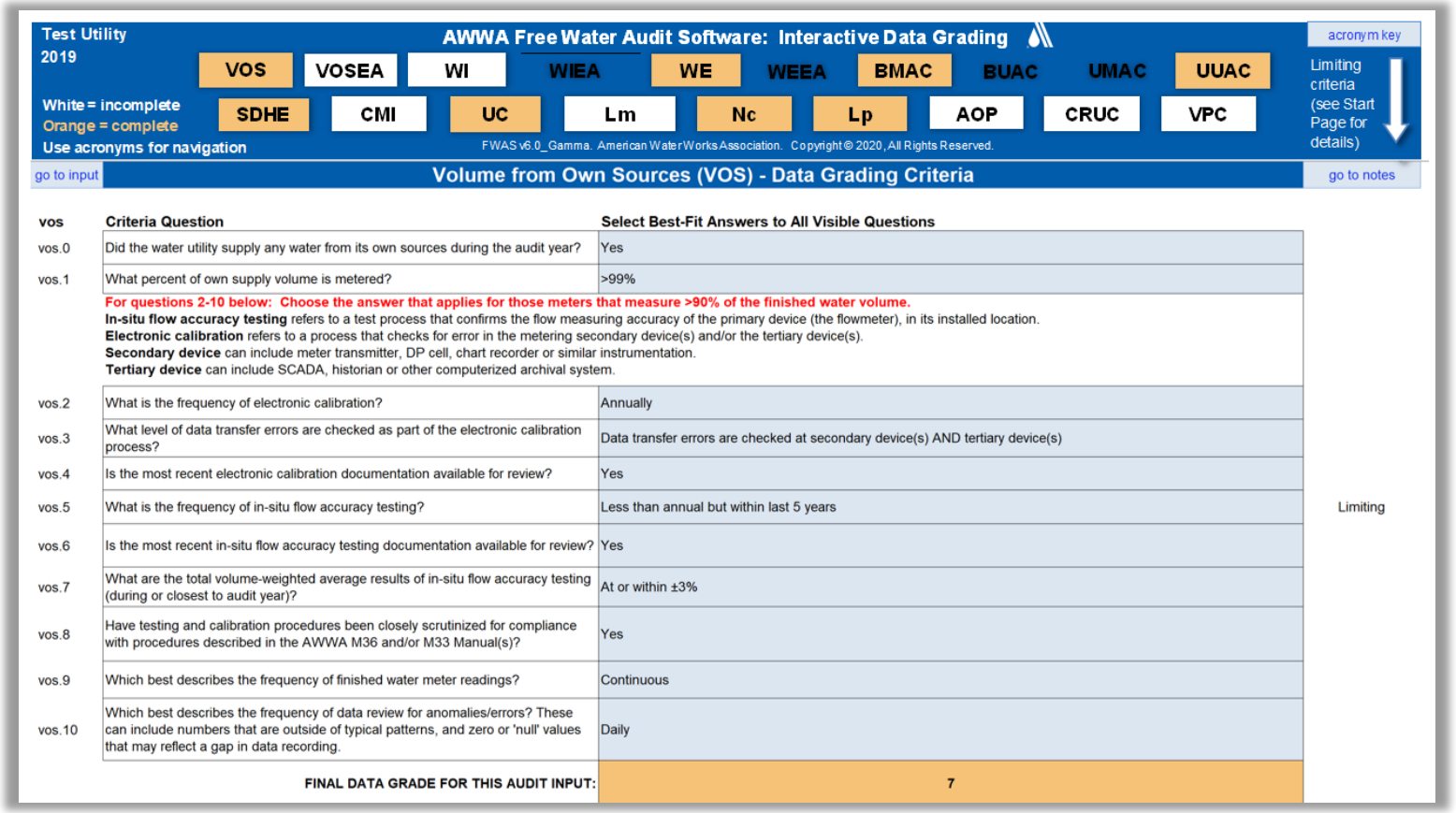
Volume from Own Sources (VOS) - Data Grading Criteria

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** refers to a test process that confirms the flow measuring accuracy of the primary device (the flowmeter), in its installed location. **Electronic calibration** refers to a process that checks for error in the metering secondary device(s) and/or the tertiary device(s). **Secondary device** can include meter transmitter, DP cell, chart recorder 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 checked at secondary device(s) AND tertiary device(s)
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)?	
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%
vos.9	Which best describes the frequency of finished water meter readings?	
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.	

FINAL DATA GRADE FOR THIS AUDIT INPUT:

AWWA Free Water Audit Software
Interactive Data Grading



Test Utility
2019

White = incomplete
Orange = complete
Use acronyms for navigation

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

Limiting criteria (see Start Page for details)

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go to input

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go to notes

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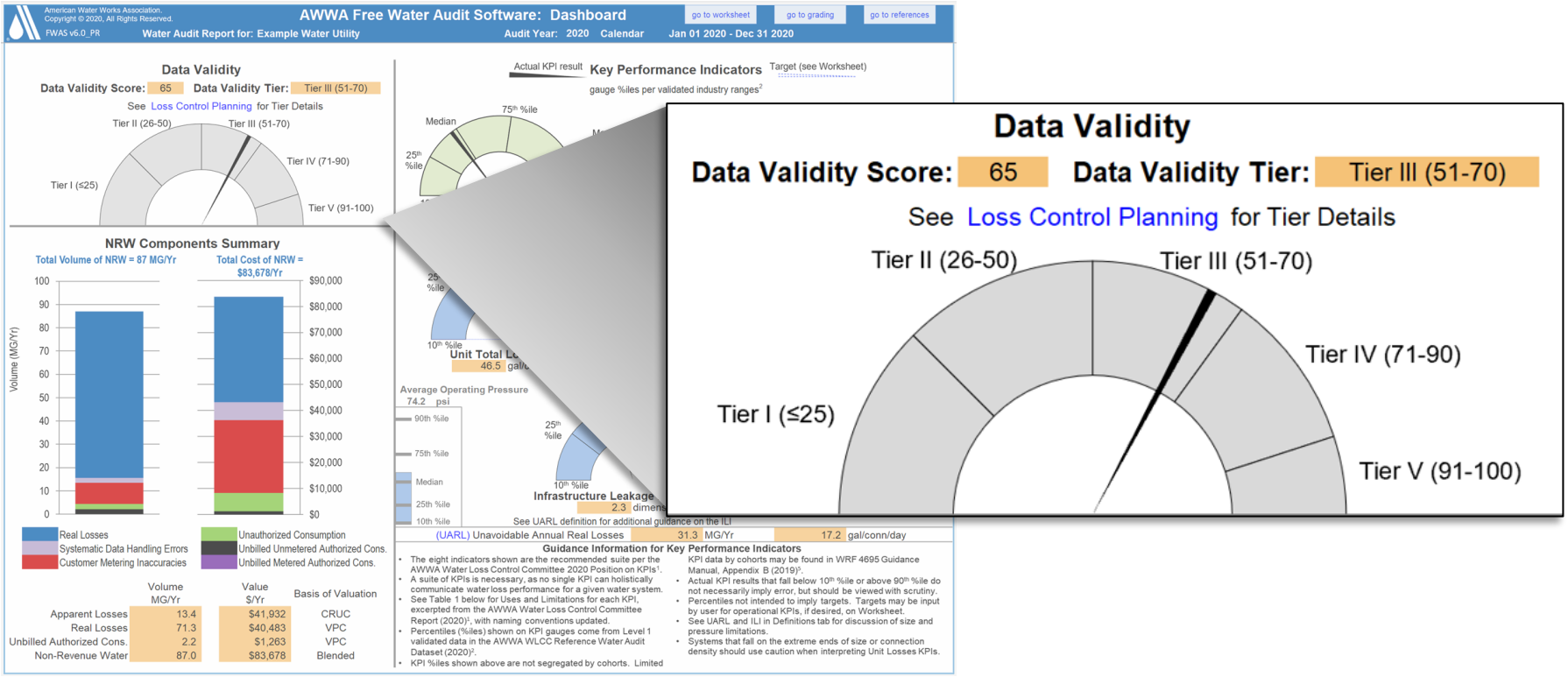
vos.3	What level of data transfer errors are checked as part of the electronic calibration process?	Data transfer errors are checked at secondary device(s) AND tertiary device(s)	
vos.4	Is the most recent electronic calibration documentation available for review?	Yes	
vos.5	What is the frequency of in-situ flow accuracy testing?	Less than annual but within last 5 years	Limiting
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)?	At or within ±3%	
vos.8	Have testing and calibration procedures been closely scrutinized for compliance with procedures described in the AWWA M36 and/or M33 Manual(s)?	Yes	
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.	Daily	
	FINAL DATA GRADE FOR THIS AUDIT INPUT:	7	

- Includes questions regarding practices, policies, and grading criteria selections
- Automated Data Grade selections
- Includes guidance for improvement to the next grade shown as ‘Limiting’ criteria

AWWA Free Water Audit Software
Quantifying Data Validity

Data Validity Score (DVS)

- A composite calculation based upon the gradings of the individual water audit components
- Represents the overall validity, or trustworthiness, of the data <u>and</u> is an indirect assessment of the utility's processes to supply and deliver water



AWWA Free Water Audit Software
What does the DVS mean for my water utility?

- ***Water Loss Control Planning Guide***
- Gives guidance on interpretation of the Data Validity Tier (DVT)
- Represents a continuum of process-based assessments
- Higher validity = more reliable assessment of water loss standing and greater loss control opportunities

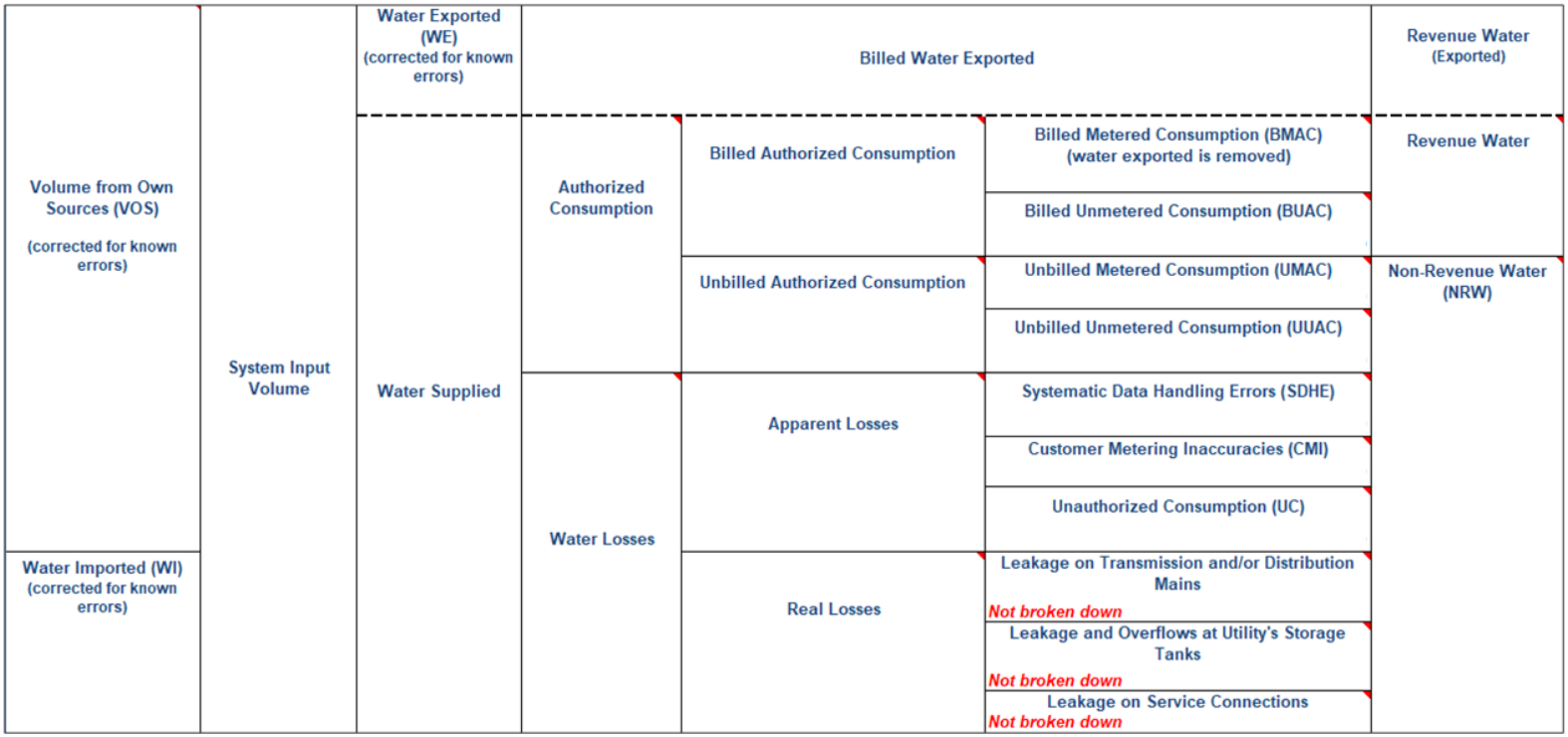
Water Loss Control Planning Guide

	Water Audit Data Validity Tier (Score Range)				
Functional Focus Area	**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.

Accuracy in the Water Balance

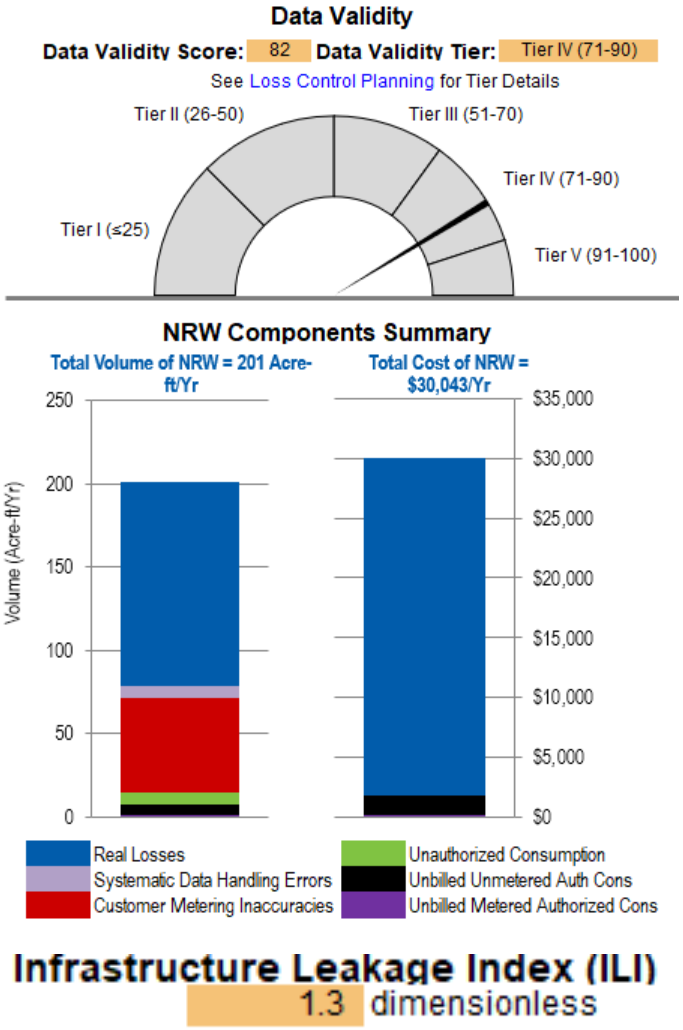
Where does error sneak in?



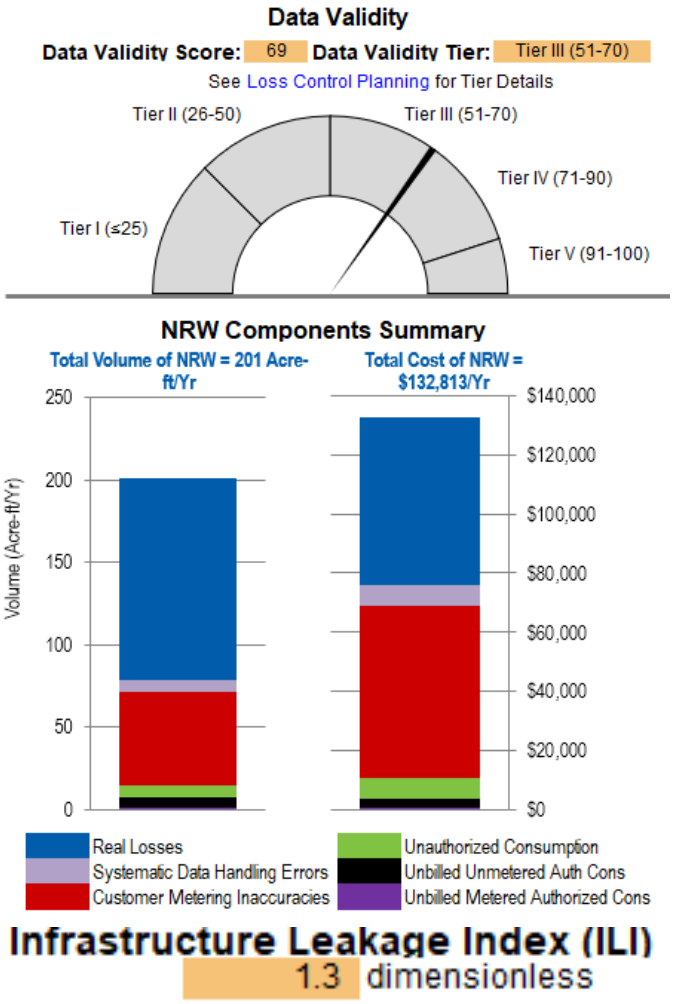
- Primary instrumentation
- Secondary data management, archival, and summary
- Interaction with data and methodology; estimation

Impacts of Data Validation for a Particular Water Utility – DVS Decreased!

Pre-Level 1 Validation



Post-Level 1 Validation



Graphics are from FWAS Dashboard worksheet

Filling out the Software

1. **Gather** data and supporting documents

   data for each input:

   complete? consistent? accurate?

3. **Enter** the input.

4. **Comment** on source of data, quality of data, etc.

5. **Select** a data validity grade for each input

Step 1 – Assemble the Supporting Documents

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

Colorado Water Loss Initiative

The Colorado Water Loss Initiative

Level 1 Water Audit Validation Session:

How to Prepare

The Level 1 Water Audit Validation will be a ~2-hour teleconference with shared screen during which your Water Audit Team and a member of the CWLI team discuss your water audit and the data that supports it.

To prepare for the session, you will need to **gather and provide to us** the following documents and data. Do the best you can! If you can't provide every item requested, please do what you are able and note any gaps in the data for us to discuss. You also have the option to schedule a pre-conference meeting with your assigned Water Audit Validator to go over any questions to ensure readiness for the validation session.

Documents to send to the CWLI Team:

Required documentation for Level 1 Validation:

- ☐ Completed **AWWA Free Water Audit Software** (Excel Spreadsheet)
- ☐ **Volume from Own Sources** broken down by month and finished water supply meter
- ☐ **Water Imported** broken down by month by meter
- ☐ **Water Exported** broken down by month by meter
- ☐ **Supply meter testing** and/or calibration documentation
- ☐ **Authorized Consumption** broken down by month and use type (e.g. charge status, water type, customer

Example of Supporting Documentation for Billed Metered Authorized Consumption

			Water Sold, UNITS = MG					
Month	*May 2017*	*June 2017*	July 2017	August 2017	September 2017	October 2017	November 2017	December 2
Single Family Residential	*31.15*	*32.81*	38.42	28.18	42.15	47.77	48.99	5
Multi Family Residential	*16.07*	*15.55*	18.54	17.84	18.49	17.65	19.29	2
Commericial/Institutional	*12.67*	*14.23*	8.78	8.96	10.84	13.01	12.91	1
Industrial	*1.20*	*1.40*	1.40	1.50	1.20	1.10	1.60	
Landscape Irrigation	*10.02*	*7.56*	2.54	4.82	8.42	10.48	11.94	1
Municipal	*3.45*	*2.88*	2.22	2.25	2.56	2.93	2.91	
Water Department	*1.42*	*1.10*	1.50	1.55	1.05	1.66	1.20	
Recycled	*8.53*	*9.11*	10.08	8.04	10.83	11.95	12.20	1

WATER AUDIT TOTALS

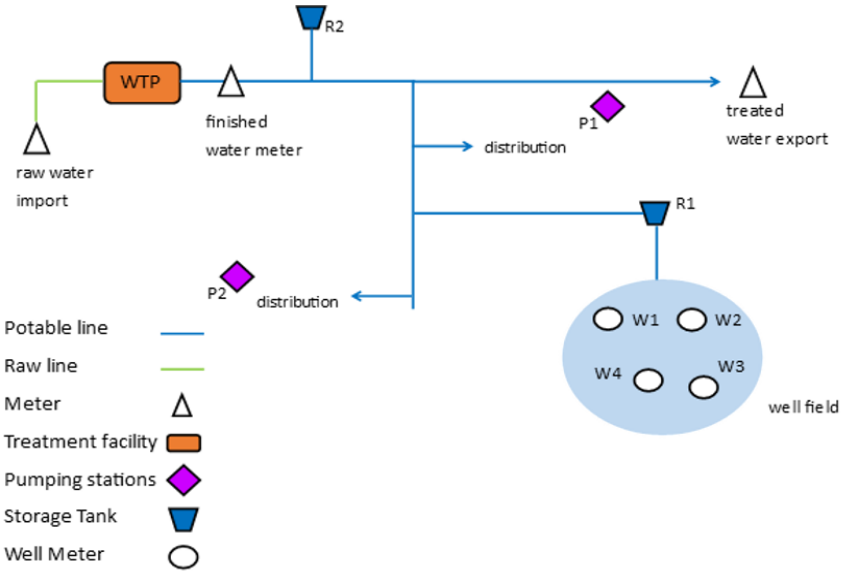
excludes recycled water accounts

Billed Metered Authorized Consumption:	1,051.33	MG	*includes SF Residential, MF Re*
Billed Unmetered Authorized Consumption:	N/A		*all billed customers have a me*
Unbilled Metered Authorized Consumption:	17.27	MG	*this includes our own facility u*
Unbilled Unmetered Authorized Consumption:			*this includes minimal flushing,*

Example of Supporting Documentation for all Water Supplied Volumes

Volume from Own Sources, Water Imported, Water Exported
UNITS = MG

Month	Import M-1	Well 1	Well 2	Well 3	Export E-1	Monthly Distribution Totals
May 2017	*125.48*	*15.33*	*11.19*	*45.61*	-	*197.60*
June 2017	*170.61*	-	*55.48*	*30.59*	-	*256.68*
July 2017	202.11	5.75	60.58	36.22	-	304.67
August 2017	185.45	2.03	37.67	32.58	-	257.74
September 2017	178.74	1.49	34.31	32.04	-	246.59
October 2017	171.39	-	25.15	-	5.18	191.36
November 2017	123.00	2.31	39.35	32.85	45.79	151.72
December 2017	49.11	5.43	58.60	35.91	22.46	126.58
January 2018	31.56	34.60	23.82	64.49	-	154.46
February 2018	7.29	31.94	22.20	61.89	-	123.32
March 2018	6.06	31.22	21.70	61.18	-	120.17
April 2018	58.44	35.56	24.43	65.44	-	183.87



Supporting Documentation

provides more detail on key values

REQUIRED	SUPPLEMENTAL
❑ Volume from Own Sources *broken down by month and meter* ❑ Water Imported *broken down by month and meter* ❑ Water Exported *broken down by month and meter* ❑ Supply Meter Test Records *for all supply meters, if conducted* ❑ Volume of Metered Consumption *broken down by month and use type/code*	❑ Customer Meter Inaccuracy derivation ❑ Average Operating Pressure derivation ❑ Customer Retail Unit Cost derivation ❑ Variable Production Cost derivation ❑ System Schematic *showing locations of Supply and Export Meters*

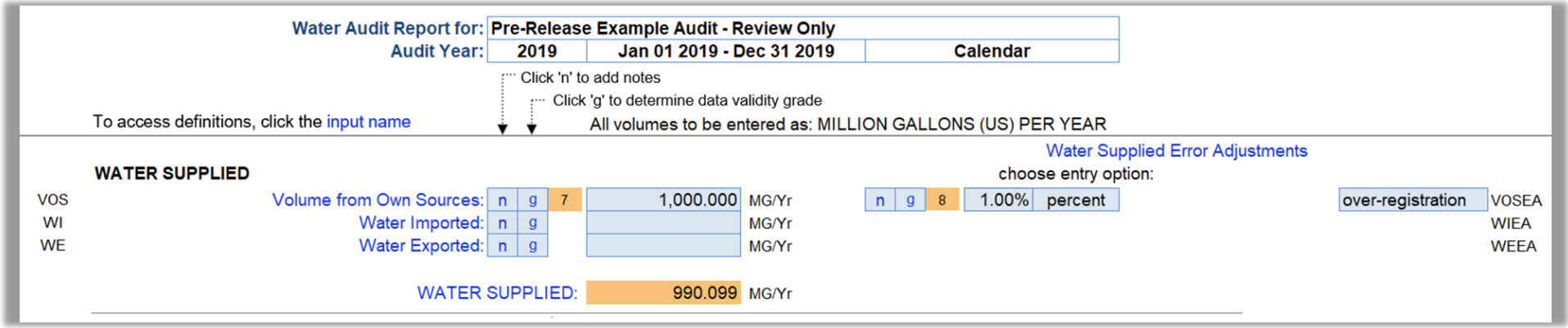
Developing the Inputs

1. Assemble supporting documents → Must-have docs
2. Develop the data inputs → Good-to-have docs

Developing the Inputs

1. Assemble supporting documents
   - → Must-have docs
   - → Good-to-have docs
2. Develop the data inputs
   - → Build it from supporting docs
   - → Look for errors. Does the data make sense?

Step 2 – Develop the Inputs



Water Audit Report for: Pre-Release Example Audit - Review Only
Audit Year: 2019 | Jan 01 2019 - Dec 31 2019 | Calendar

Click 'n' to add notes
Click 'g' to determine data validity grade

To access definitions, click the input name

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

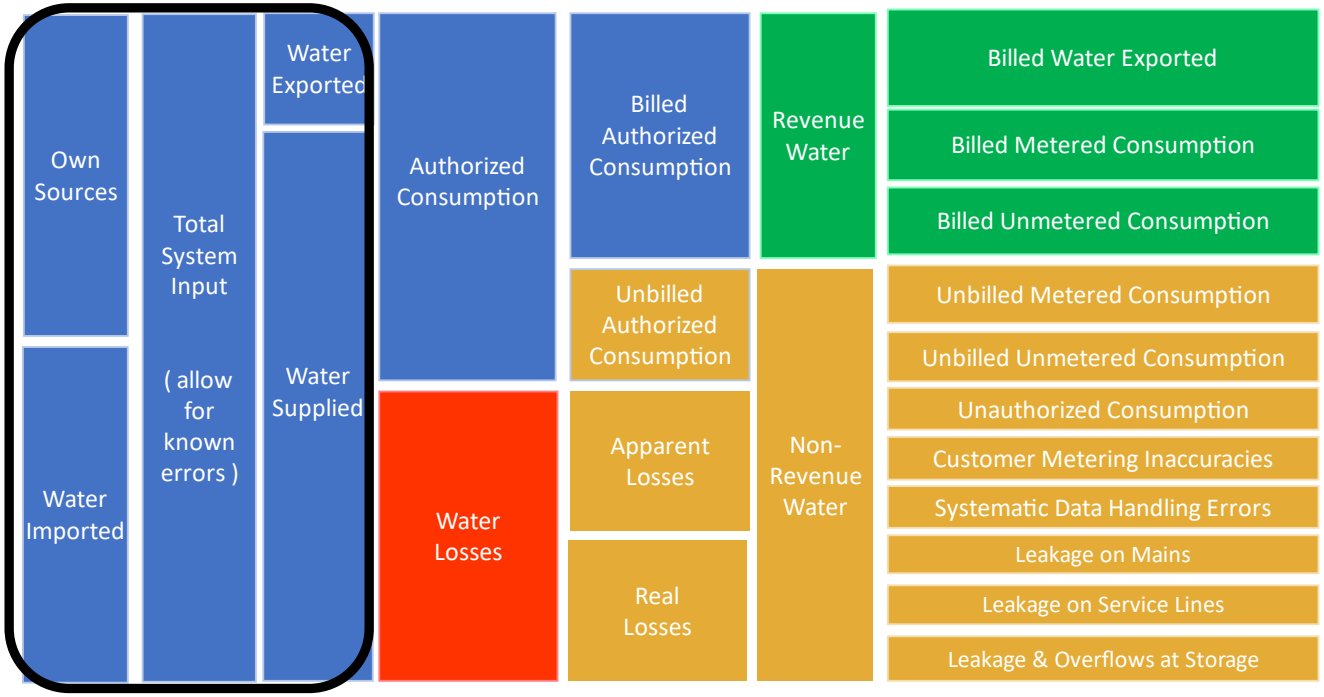
WATER SUPPLIED

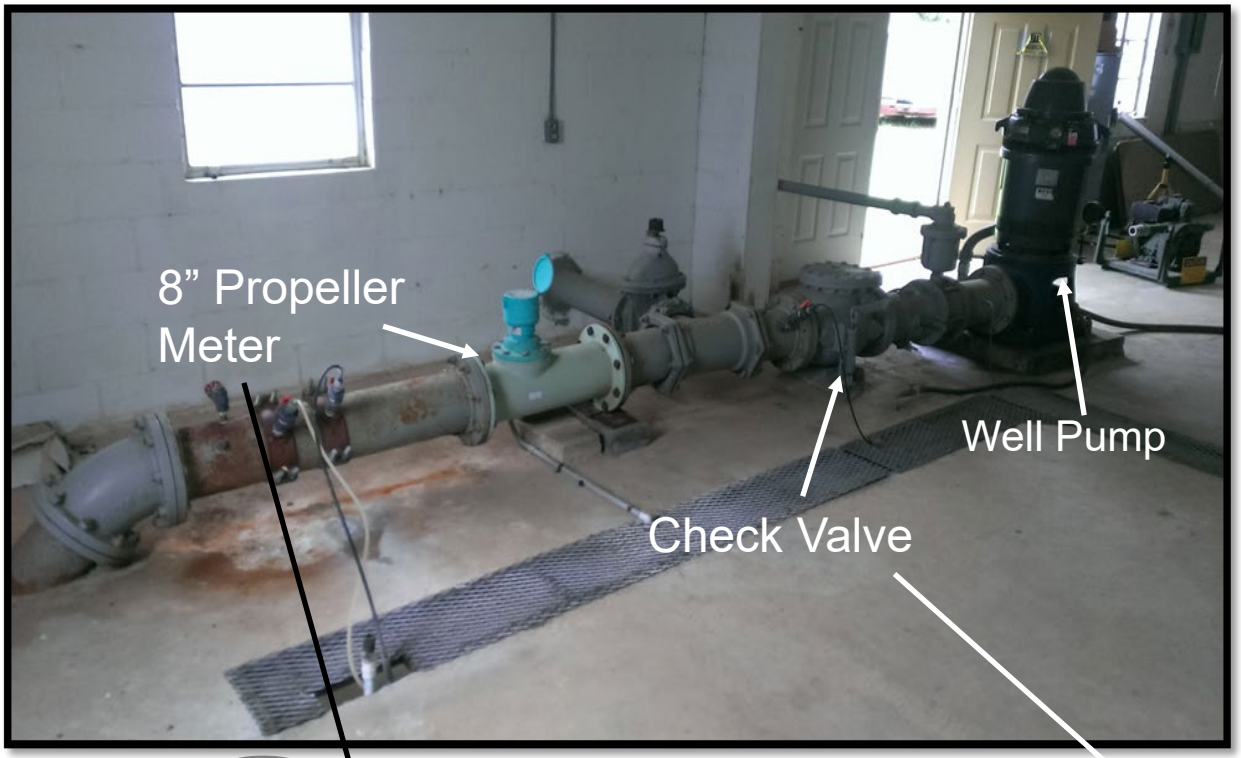
								Water Supplied Error Adjustments				
								choose entry option:				
VOS	Volume from Own Sources:	n	g	7	1,000.000	MG/Yr	n g 8	1.00%	percent	over-registration	VOSEA
WI	Water Imported:	n	g			MG/Yr					WIEA
WE	Water Exported:	n	g			MG/Yr					WEEA
	WATER SUPPLIED:				990.099	MG/Yr					

- **Develop the Input**
  - Trace from production reports
  - Trace from testing reports
- **Look for Potential Errors**
  - Missing or extra volumes
  - Mismatched timeframe
  - Error adjustment should be a weighted average of test results (if available)
  - Wrong + or – on error adjustment

Potential Errors in Water Supplied

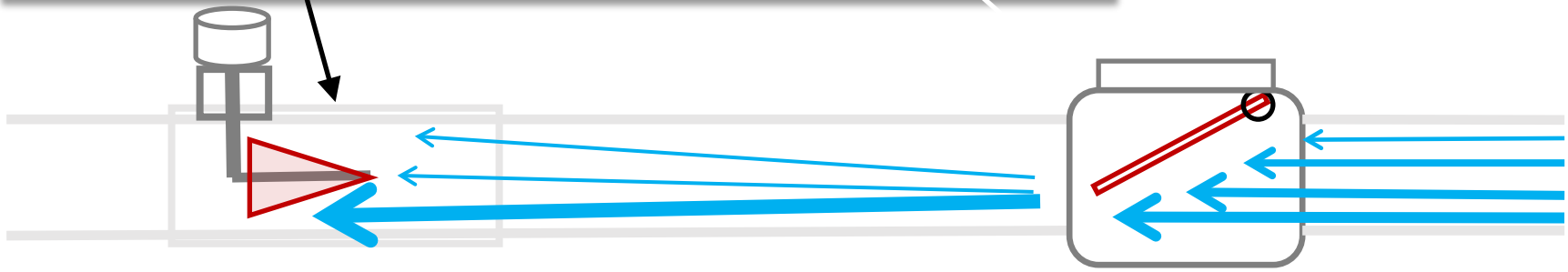
- Meter wear
- Meter location
- Meter selection
- Meter programming
- Flow data archiving





Accuracy results from MFR test bench: 99.5%

Accuracy results from in-situ test: 142.2%



Courtesy MESCO

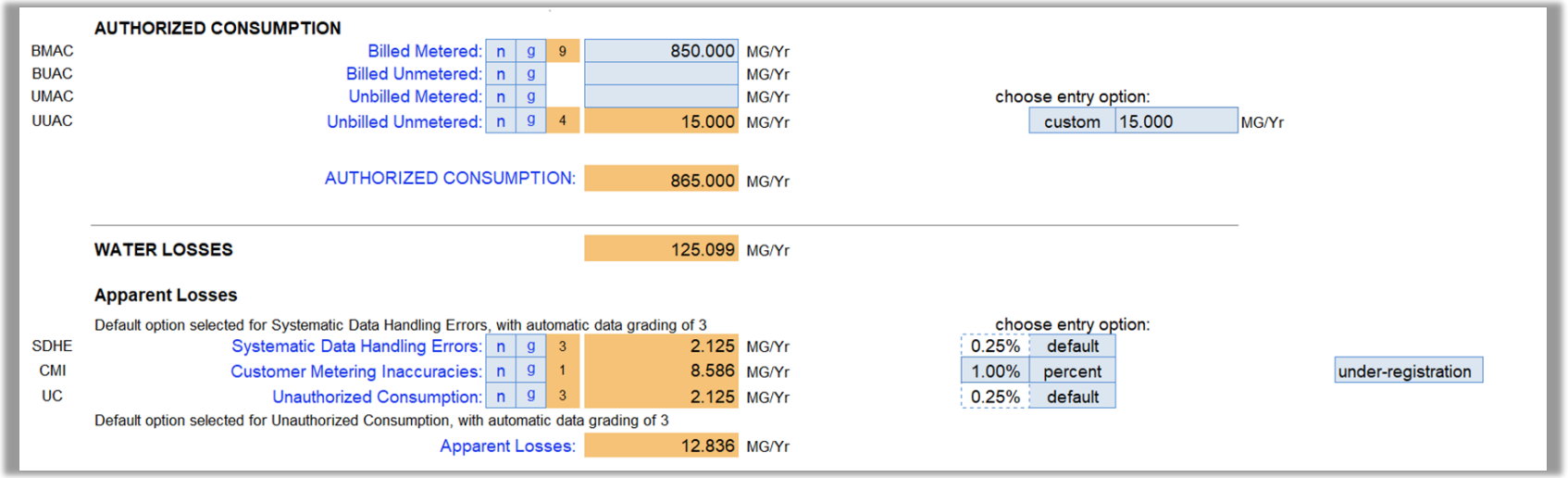
Flow Data Archiving

- Production flow data should be reviewed every business day for data gaps
- Gaps occur due to:
  - Unplanned interruption: lightning strike, power failure
  - Planned interruption: instrumentation calibration
- Gaps in water flow data should be quantified and added back to the daily total

Example of Water Pumping Data Gaps an		
8/15/2012, hrs	High Service Pumping Rate, mgd actual flow	High Service Pumping Rate, mgd raw recorded data
0:00	8.69	8.69
1:00	8.65	8.65
2:00	8.32	8.32
3:00	8.11	8.11
4:00	7.94	0
5:00	8.02	0
6:00	8.44	0
7:00	8.98	0
8:00	9.34	0
9:00	9.25	0
10:00	9.17	0
11:00	9.12	9.12
12:00	9.27	9.27
13:00	9.22	9.22
14:00	9.08	9.08
15:00	8.99	8.99
16:00	9.14	9.14
17:00	9.18	9.18
18:00	9.25	9.25
19:00	9.22	9.22
20:00	8.82	8.82
21:00	8.78	8.78
22:00	8.75	8.75
23:00	8.71	8.71
0:00	8.68	8.68
Total	**212.43**	**151.29**
Average	**8.85**	**6.30**
Difference		**2.55**

(Source: AWWA M36 Publication, 4th Ed.)

Step 2 – Develop the Inputs



AUTHORIZED CONSUMPTION

BMAC	Billed Metered:	n	g	9	850.000	MG/Yr		
BUAC	Billed Unmetered:	n	g			MG/Yr		
UMAC	Unbilled Metered:	n	g			MG/Yr	choose entry option:	
UUAC	Unbilled Unmetered:	n	g	4	15.000	MG/Yr	custom 15.000	MG/Yr
	AUTHORIZED CONSUMPTION:				865.000	MG/Yr		

WATER LOSSES 125.099 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	2.125	MG/Yr	0.25%	default	
CMI	Customer Metering Inaccuracies:	n	g	1	8.586	MG/Yr	1.00%	percent	under-registration
UC	Unauthorized Consumption:	n	g	3	2.125	MG/Yr	0.25%	default	

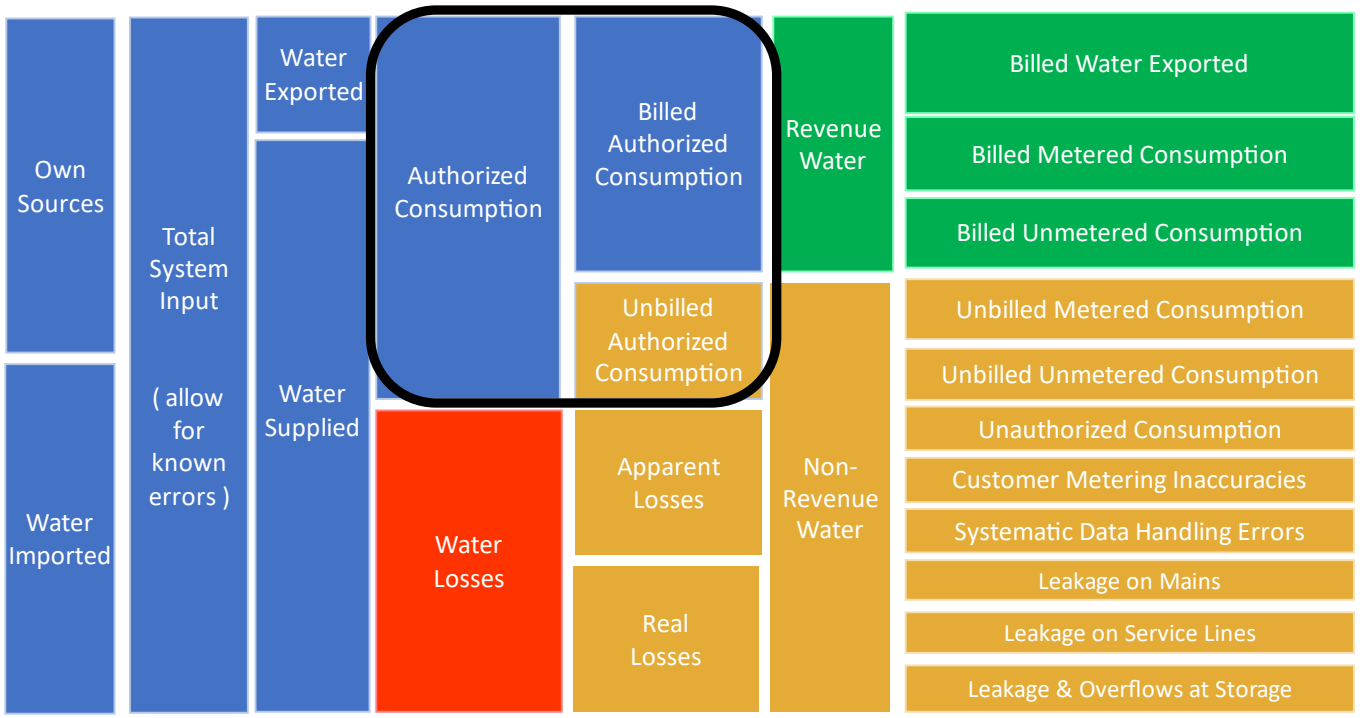
Default option selected for Unauthorized Consumption, with automatic data grading of 3

Apparent Losses: 12.836 MG/Yr

- **Develop the Input**
  - Trace from billing reports
  - Trace from flushing (etc) tracker
- **Look for potential errors**
  - Billing report
  - Double counting Water Exported in Billed Metered
  - Double counting Unbilled Metered in Billed Metered
  - Including leaks / breaks in Unbilled Unmetered

Potential Errors in Authorized Consumption

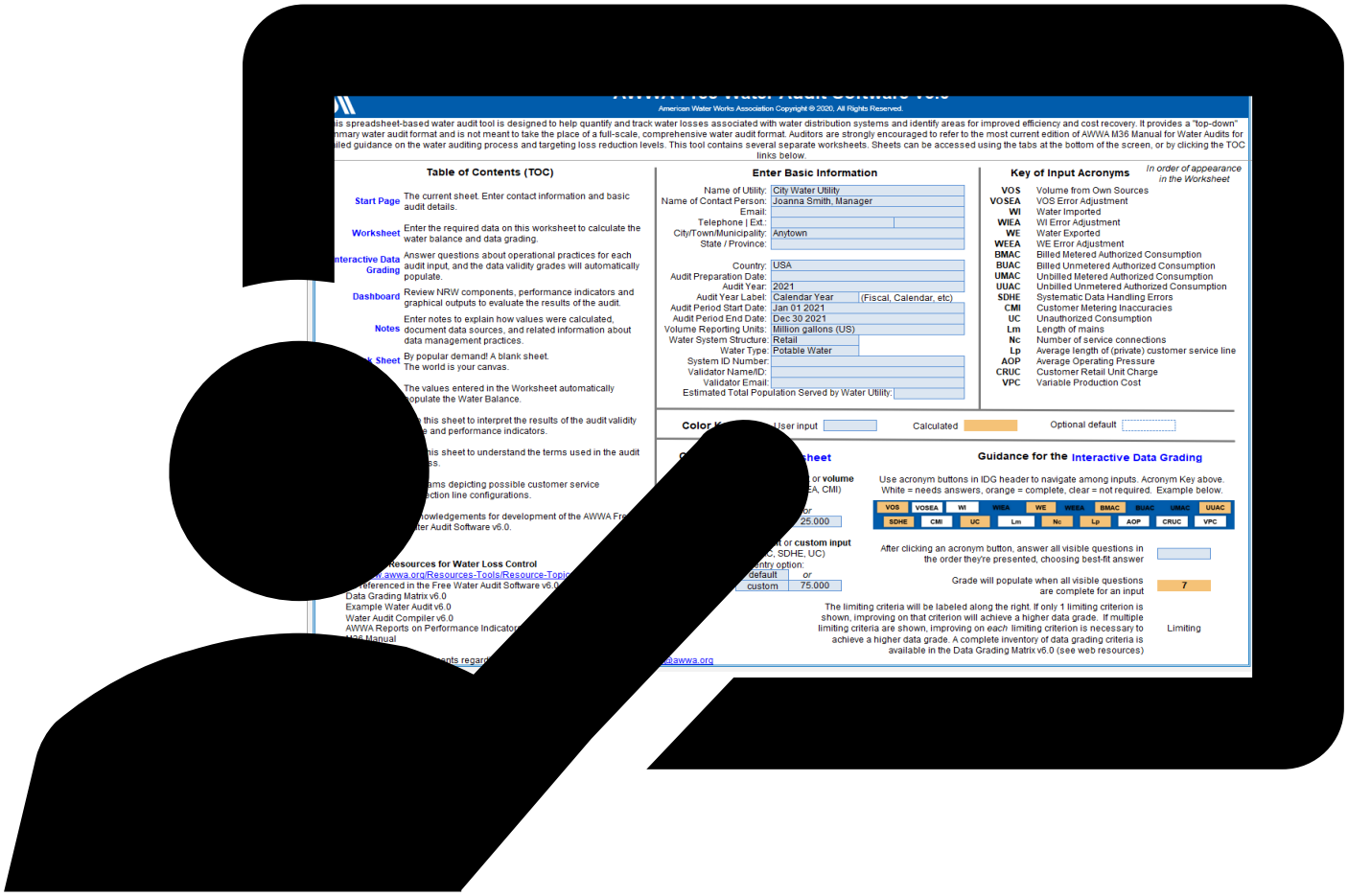
- Duplicate volumes
- Non-potable volumes
- Missing volumes
- Mismatched timeframes



Developing the Inputs

1. Assemble supporting documents
   - → Must-have docs
   - → Good-to-get docs
2. Develop the data inputs
   - → Build it from supporting docs
   - → Look for errors. Does the data make sense?

Demonstration:
AWWA Free Water Audit Software



Knowledge Check

The AWWA Free Water Audit Software…

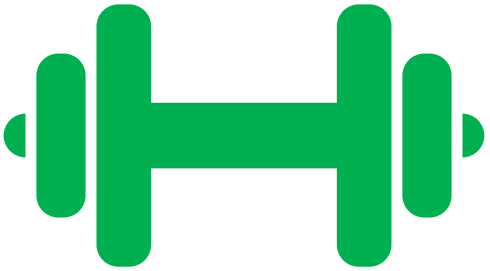
A. reports water losses as a percentage of supply input.

B. calculates Unaccounted-For Water.

C. is the industry standard tool for quantifying water losses.

D. is expensive.

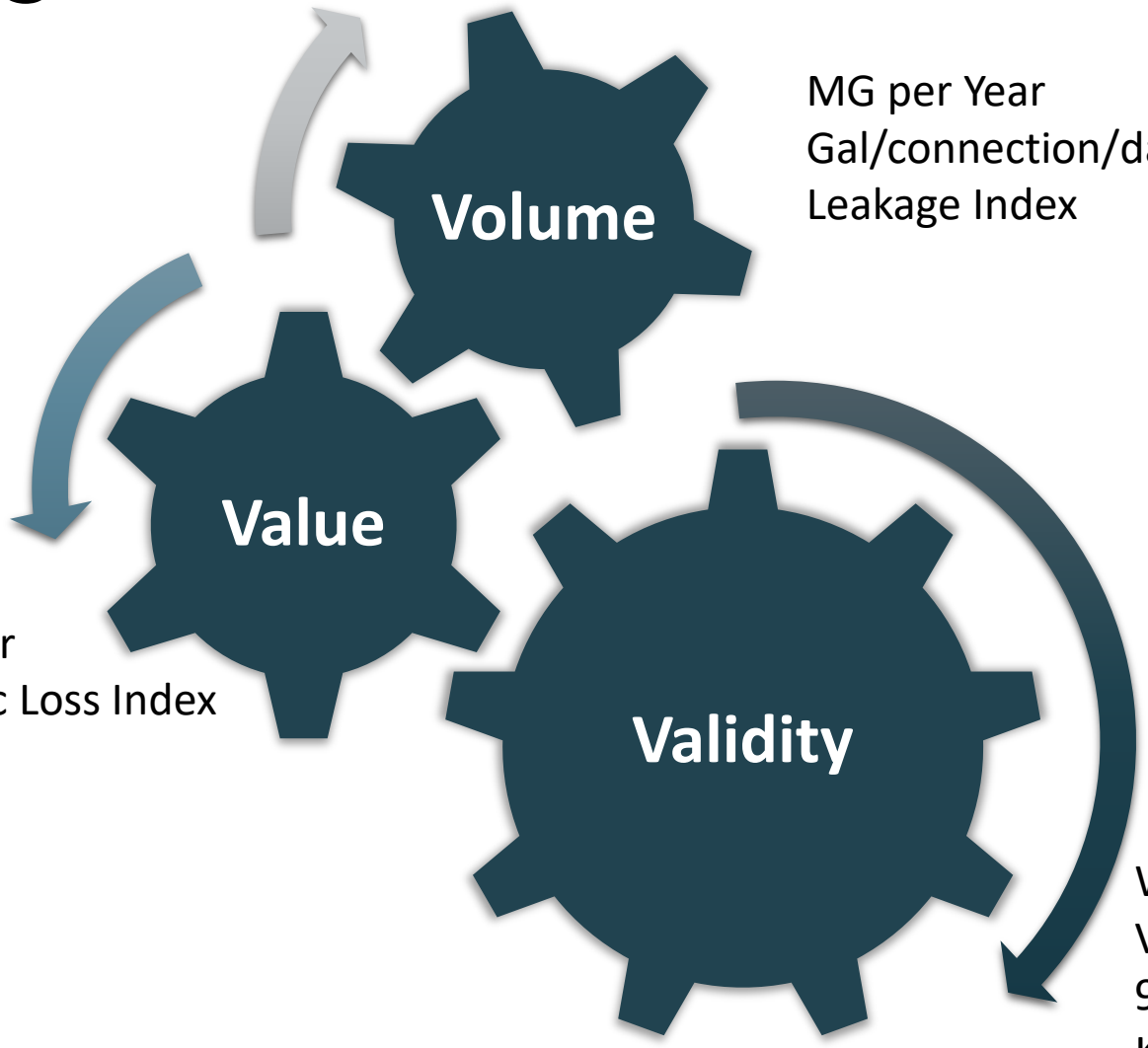
E. None of the above



Group Exercise: Developing the Inputs

Data Validity Grading

3-Vs



MG per Year
Gal/connection/day
Leakage Index

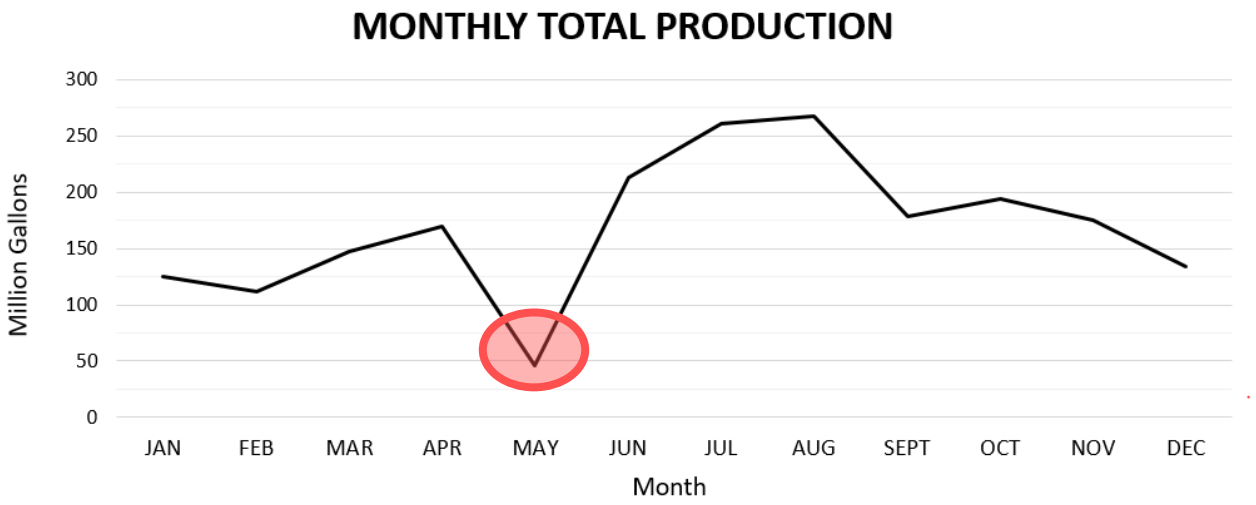
$ per Year
Economic Loss Index

Water Audit Data
Validity Score
95% Confidence Limits
Key Data Input Grades

Water Audit

2. Evaluate data reliability

Complete? Consistent? Accurate?



Does the data story make sense?

Data quality matters!

inaccuracy & uncertainty in inputs → inaccuracy & uncertainty in results

Sources of error:

- Instruments
- Databases
- People
- Missing information

Data Validity Grades

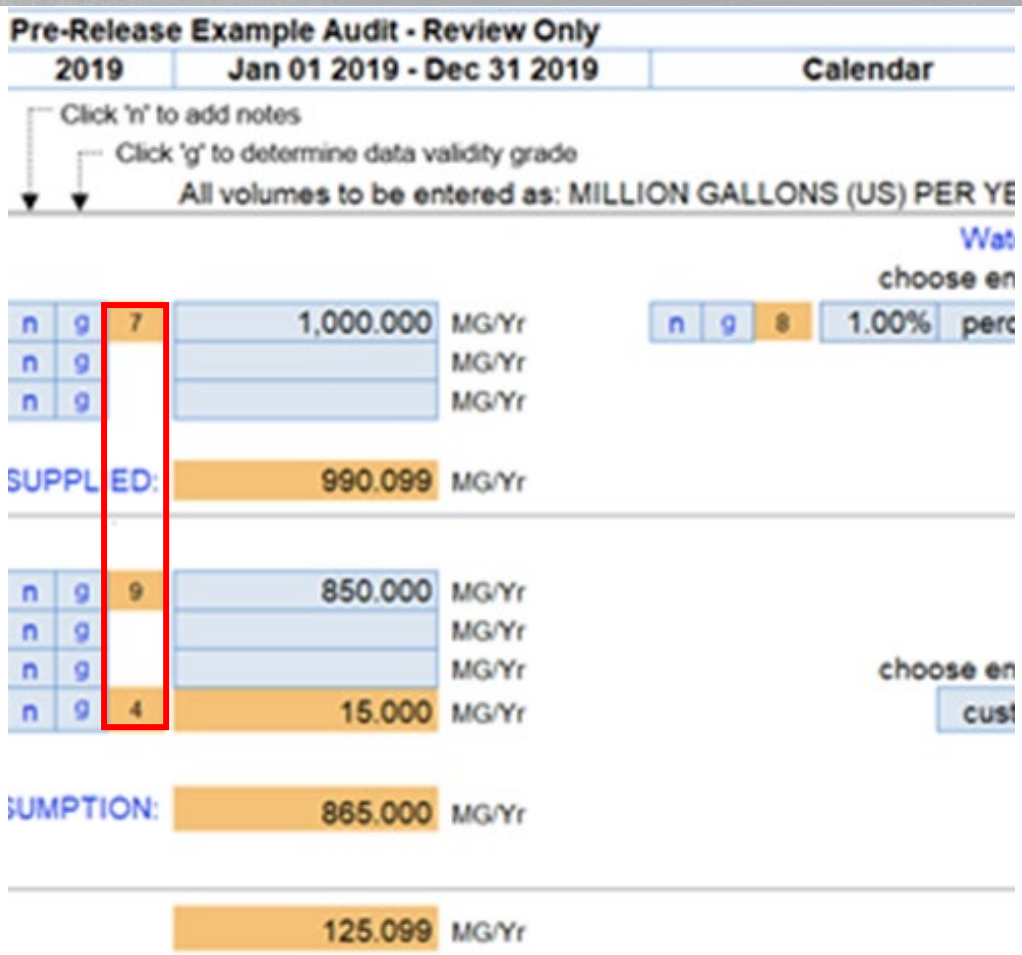
Data validity grades (DVGs) document utility practices of:

- Data collection
- Data review
- Instrument maintenance

Each audit input is automatically assigned a DVG between 1 and 10 based on answers to IDG criteria questions

DVG criteria are predominantly qualitative

DVGs are NOT a measure of accuracy!



COLORADO
Colorado Water Conservation Board
Department of Natural Resources

Colorado Water Loss Initiative

Data Validity Grading

v5

All volumes to be entered as: ACRE-FEET PER YEAR

To select the correct data grading for each input, determine the highest grade where the

WATER SUPPLIED

AUTHORIZED CONSUMPTIO

v6

Water Audit Report for:	Pre-Release Example Audit - Review Only	
Audit Year:	2019	Jan 01 2019 - Dec 31 2019

Click 'n' to add notes

Click 'g' to determine data validity grade

To access definitions, click the input name

All volumes to be entered as: MILLIC

WATER SUPPLIED

Volume from Own Sources:	n	g	1,000.000	MG/Yr
Water Imported:	n	g		MG/Yr
Water Exported:	n	g		MG/Yr
WATER SUPPLIED:			990.099	MG/Yr

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Data Validity Grading

v5

All volumes to be entered as: ACRE-FEET PER YEAR

To select the correct data grading for each input, determine the highest grade where the

WATER SUPPLIED

AUTHORIZED CONSUMPTIO

v6

Water Audit Report for: **Pre-Release Example Audit - Review Only**

Audit Year: **2019** **Jan 01 2019 - Dec 31 2019**

Click 'n' to add notes

Click 'g' to determine data validity grade

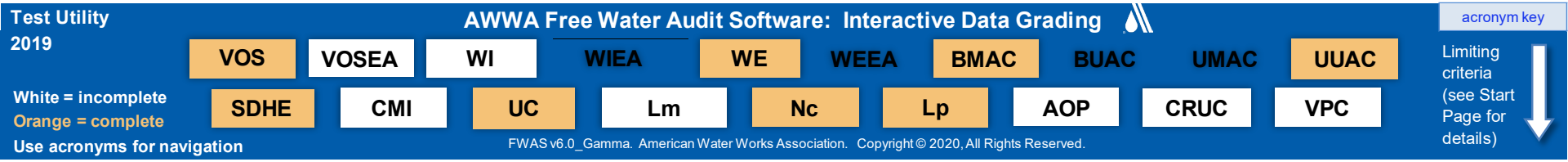
To access definitions, click the input name

All volumes to be entered as: MILLIC

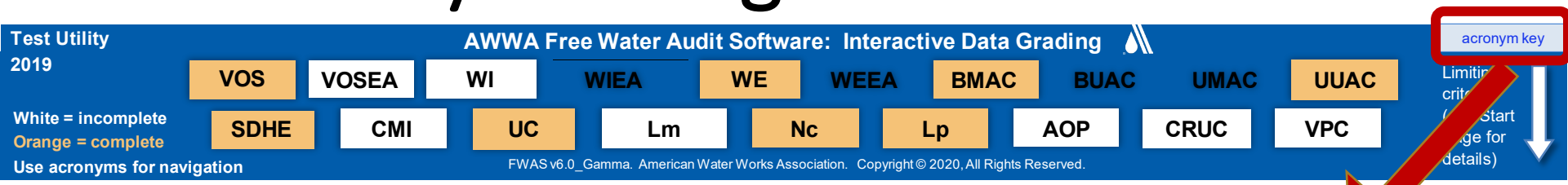
WATER SUPPLIED

Volume from Own Sources:	n	g	1,000.000	MG/Yr
Water Imported:	n	g		MG/Yr
Water Exported:	n	g		MG/Yr
WATER SUPPLIED:			990.099	MG/Yr

Data Validity Grading



Data Validity Grading



Key of Input Acronyms *In order of appearance in the Worksheet*

VOS	Volume from Own Sources
VOSEA	VOS Error Adjustment
WI	Water Imported
WIEA	WI Error Adjustment
WE	Water Exported
WEEA	WE Error Adjustment
BMAC	Billed Metered Authorized Consumption
BUAC	Billed Unmetered Authorized Consumption
UMAC	Unbilled Metered Authorized Consumption
UUAC	Unbilled Unmetered Authorized Consumption
SDHE	Systematic Data Handling Errors
CMI	Customer Metering Inaccuracies
UC	Unauthorized Consumption
Lm	Length of mains
Nc	Number of service connections
Lp	Average length of (private) customer service line
AOP	Average Operating Pressure
CRUC	Customer Retail Unit Charge
VPC	Variable Production Cost

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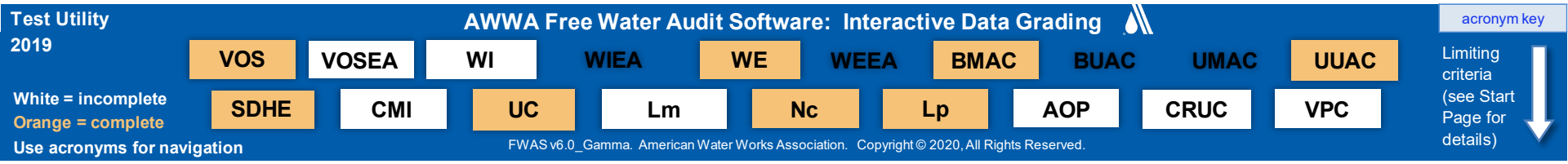
v6

Data Validity Grading



Use acronym buttons in IDG header to navigate among inputs. Acronym Key above.
White = needs answers, orange = complete, clear = not required.

After clicking an acronym button, answer all visible questions in the order they're presented, choosing best-fit answer

Grade will populate when all visible questions are complete for an input

7

The limiting criteria will be labeled along the right. If only 1 limiting criterion is shown, improving on that criterion will achieve a higher data grade. If multiple limiting criteria are shown, improving on each limiting criteria is necessary to achieve a higher data grade. A complete inventory of data grading criteria is available in the Data Grading Matrix v6.0 (see web resources)

Limiting

Interactive Data Grading

v6

Test Utility
2019

White = incomplete
Orange = complete
Use acronyms for navigation

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

Limiting criteria (see Start Page for details)

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 refers to a test process that confirms the flow measuring accuracy of the primary device (the flowmeter), in its installed location.
Electronic calibration refers to a process that checks for error in the metering secondary device(s) and/or the tertiary device(s).
Secondary device can include meter transmitter, DP cell, chart recorder 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 checked at secondary device(s) AND tertiary device(s)
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)?	
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%
vos.9	Which best describes the frequency of finished water meter readings?	
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.	

FINAL DATA GRADE FOR THIS AUDIT INPUT:

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v6

Interactive Data Grading

Test Utility 2019

AWWA Free Water Audit Software: Interactive Data Grading

acronym key

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

White = incomplete
Orange = complete
Use acronyms for navigation

Limiting criteria (see Start Page for details)

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	
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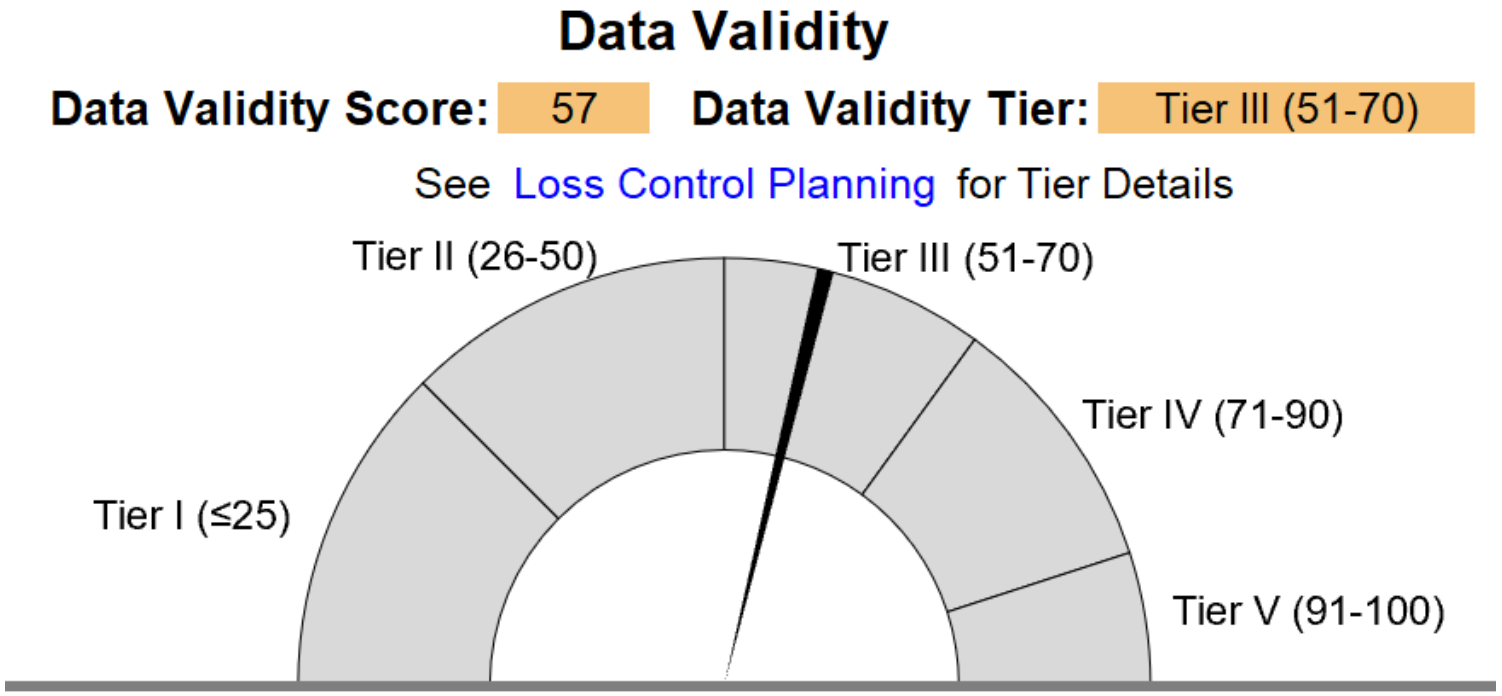
	For questions 2-10 below: Choose the answer that applies for those meters that measure >90% of the finished water volume. **In-situ flow accuracy testing** refers to a test process that confirms the flow measuring accuracy of the primary device (the flowmeter), in its installed location. **Electronic calibration** refers to a process that checks for error in the metering secondary device(s) and/or the tertiary device(s). **Secondary device** can include meter transmitter, DP cell, chart recorder 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 checked at secondary device(s) AND tertiary device(s)	
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	Limiting
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)?	At or within ±3%	
vos.8	Have testing and calibration procedures been closely scrutinized for compliance with procedures described in the AWWA M36 and/or M33 Manual(s)?	Yes	
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.	Daily	
	FINAL DATA GRADE FOR THIS AUDIT INPUT:	**7**	

Dashboard


Data Validity
Data Validity Score: 57
Data Validity Tier: Tier III (51-70)
See Loss Control Planning for Tier Details
Tier II (26-50)
Tier III (51-70)
Tier IV (71-90)
Tier I (≤25)
Tier V (91-100)

Water Loss Control Planning Guide

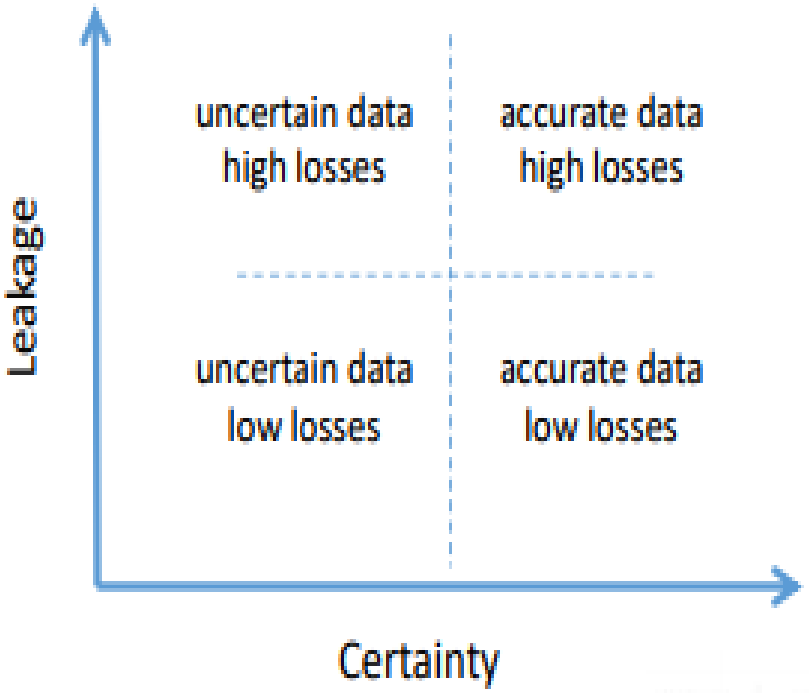
	Water Audit Data Validity Tier (Score Range)				
Functional Focus Area	**Tier I (1-25)**	**Tier II (26-50)**	**Tier III (51-70)**	**Tier IV (71-90)**	**Tier V (91-100)**
Audit Data Collection	Launch auditing and loss control team; address supply metering deficiencies	Analyze business process for customer 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.

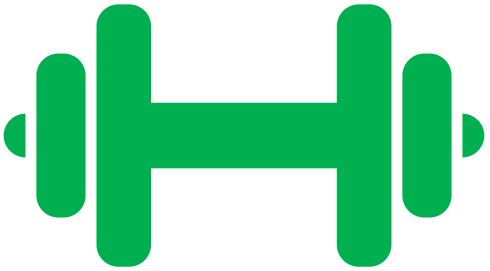
The BEST(?) Number

100

The BEST(?) Number



VS.



Group Exercise: Data Validity Grades

Level 1 Validation

Purpose of Level 1 Validation

1) review of audit methodology and volume determination

2) review of Data Validity Grade selection

goals: quality and consistency

Purpose of Level 1 Validation

1) review of audit methodology and volume determination
2) review of Data Validity Grade selection

Level 1 Validation Tools:

- Discussion with Validator
- Supporting Documentation

Data quality matters!

inaccuracy & uncertainty in inputs → inaccuracy & uncertainty in results

Sources of error:

- Instruments
- Databases
- People
- Missing information

Levels of Validation

Water audit validation aims to:

- Identify and correct errors
- Evaluate and communicate uncertainty

Level 1 – interview & summary records

Level 2 – deep data review

Level 3 – new data from the field

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WRF #4372B:

WATER AUDITS IN THE UNITED STATES: A REVIEW OF DATA VALIDITY AND RESULTS

Data quality – the validity, or trustworthiness, of the data

Water Audit Results Across the Country

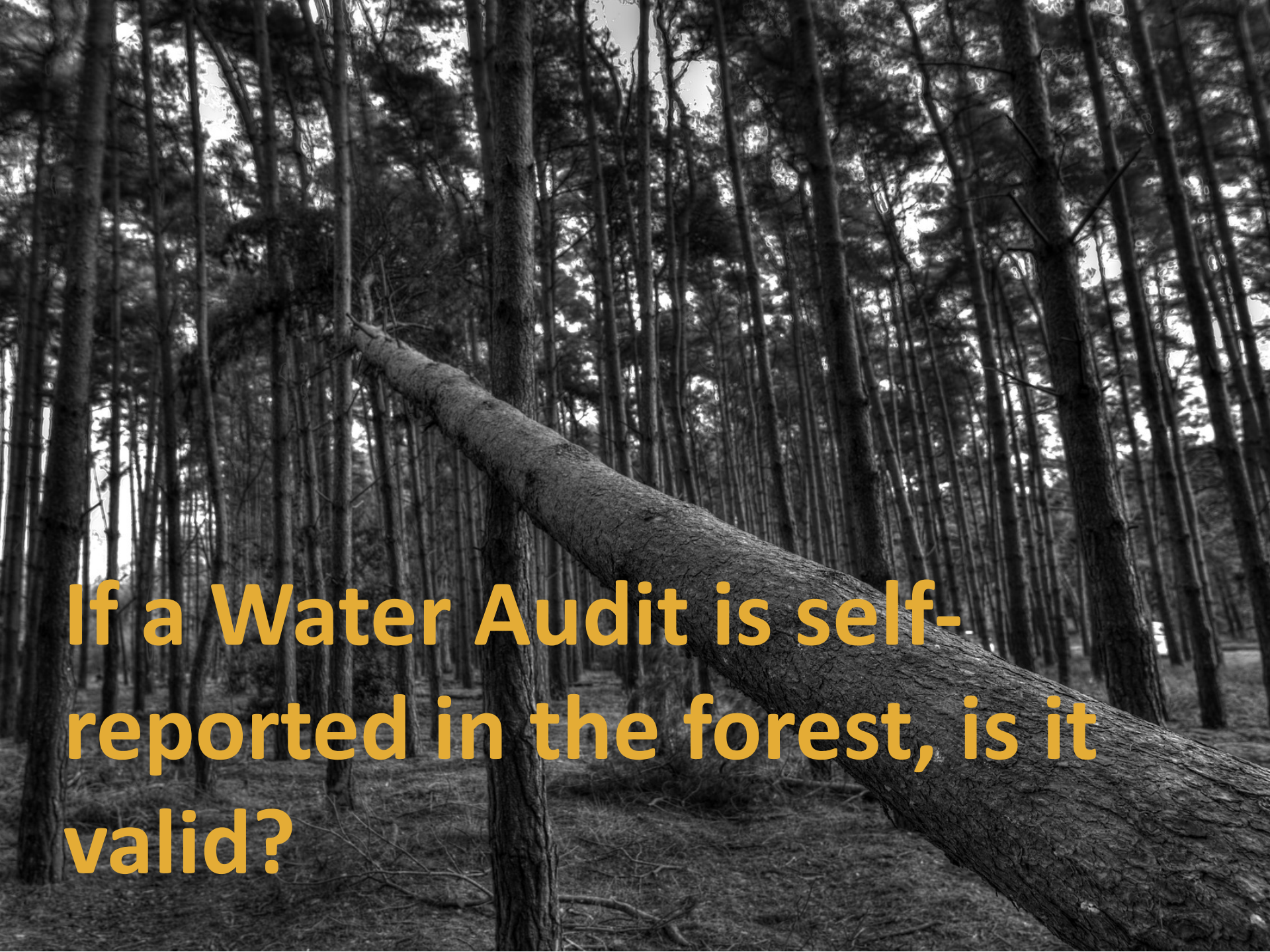
- *Water Research Foundation 4372B*

- many audits are **unrealistic**
  - *more training (ie GA, TN) produces fewer unrealistic audits*
  - *even level 1 validation doesn't fully eliminate unrealistic audits*

	CA	DRBC	GA	TN	TX
total audits	300	517	452	629	2,646
# of unrealistic audits	100	130	74	122	1,065
% of unrealistic audits	*33%*	*25%*	*16%*	*19%*	*40%*

sources of uncertainty:

- data source quality (primary measurement or secondary data management)
- methodology (use of the software, selection of data)


If a Water Audit is self-reported in the forest, is it valid?

WRF #4639:

Establishing Water Utility Guidance and Methodology for Water Audit Validation

Data validation – a quality control process conducted to verify, and improve as needed, the data inputs and gradings of the water audits submitted by water utilities.

Water Loss Audit validation – does not make data inputs or gradings "right" or "wrong", but merely aligns them with the actual conditions that occurred in the operation of the utility for the audit year

Level 1 -- Top down Data Review

Level 2 -- Top down Data Mining Review

Level 3 -- Bottom up Field Investigation

2016 UWMP Submitted Data - Unfiltered

	STATISTIC	2016 n = 292 *min*	2016 n = 292 *median*	2016 n = 292 *max*	UNIT
financial	Customer Retail Unit Cost	$0.00	$3.93	$180,097.61	$ / 1,000 gal
	Variable Production Cost	$0.00	$1,315.45	$25,007,000.00	$ / million gal
	NRW as % of Operating Cost	0.00%	3.54%	242305%	% of operating cost
volumetric	Apparent Losses	-4.34	6.36	122.3	gal/ serv conn / day
	Real Losses (serv conns)	-35	19.46	334.54	gal/ serv conn / day
	Real Losses (pressure)	-0.66	0.371	5.31	gal/ serv conn / day / psi
	ILI	-3.03	1.18	17.84	CARL / UARL
	Data Validity Score	2.35	75.33	98.27	points out of 100

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WRF #4372B:

Water Audits in the United States: A Review of Data Validity and Results

WRF #4639:

Establishing Water Utility Guidance and Methodology for Water Audit Validation

What does Level 1 water audit validation do?

The Level 1 water audit validation aims to:

- Confirm the accurate application of AWWA M36 water audit methodology and terminology to the utility-specific situation
- Identify/adjust any evident inaccuracies
- Validation of best-fit IDG answers, and understanding the answers in full context of the utility operations

In meeting these goals, the Level 1 validation process results in:

- Data validity grades that reflect utility practices
- Identification of macro-level inaccuracies
- Recommendations for advanced validation activities

What does Level 1 water audit validation *NOT* do?

Level 1 water audit validation is the least rigorous level of validation. The effort and time required to complete Level 1 validation are relatively small. Level 1 water audit validation does not:

- Correct inaccuracies in raw data that may affect summary data and audit inputs
- Investigate data processing and handling to identify and correct inaccuracies
- Study instrument accuracy through field tests to improve the certainty of the water audit
- Corroborate the volume of Real Losses with bottom-up or field investigations of leakage

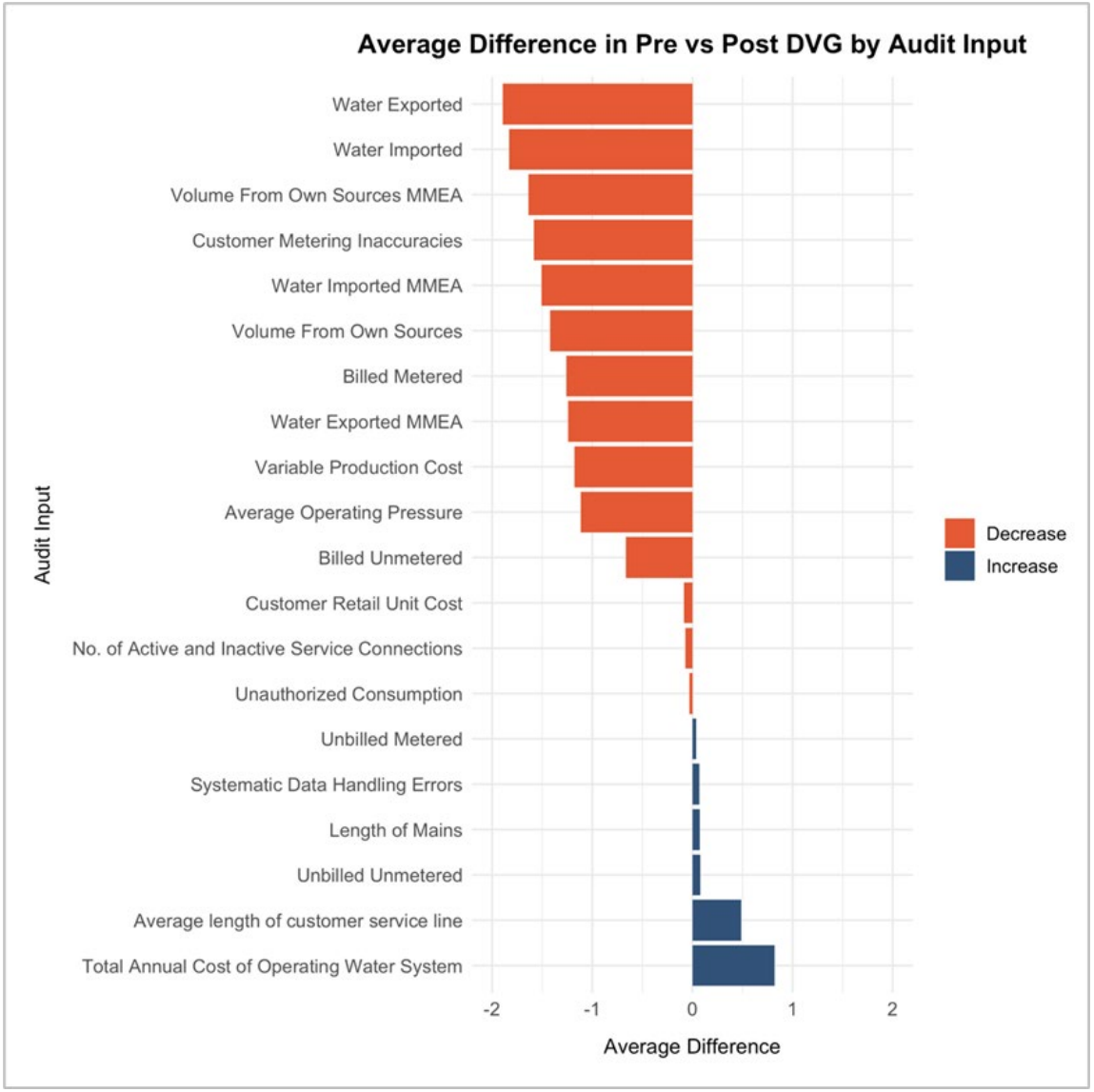
WRF #5057:
Update to Level 1 Validation Guidance Manual

Water Research Foundation℠

- **New chapter on AWWA Software v6** that describes the major changes from v5 and how they affect the validation process. This manual assumes that the user is validating a water audit completed using the AWWA Software v6.
- **New content related to audit input validation** that emphasizes key points of consideration when reviewing the methodology used to determine specific input values.
- **Real world examples of supporting documentation** for each audit input, as well as idealized versions to make best practices clear.
- **Updated language** throughout the manual to match AWWA Software v6 and to clarify confusing or ambiguous terminology.
- **Summary of research** related to certification programs and the effect of validation in North America.
- **Revisions based on industry feedback** that was collected from a dedicated advisory group of water loss professionals familiar with the first edition of the manual.

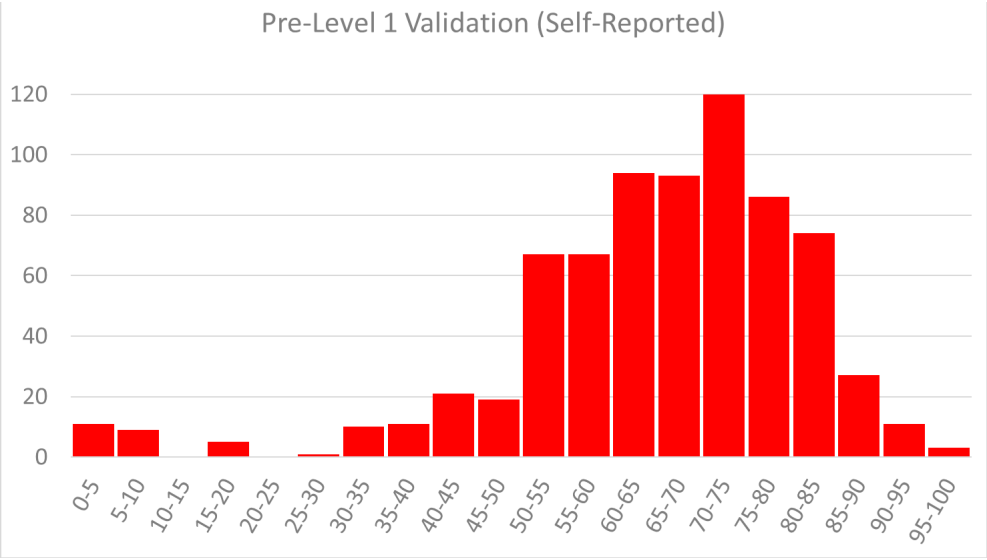
Pre-Validated vs. Post-Validated Audits

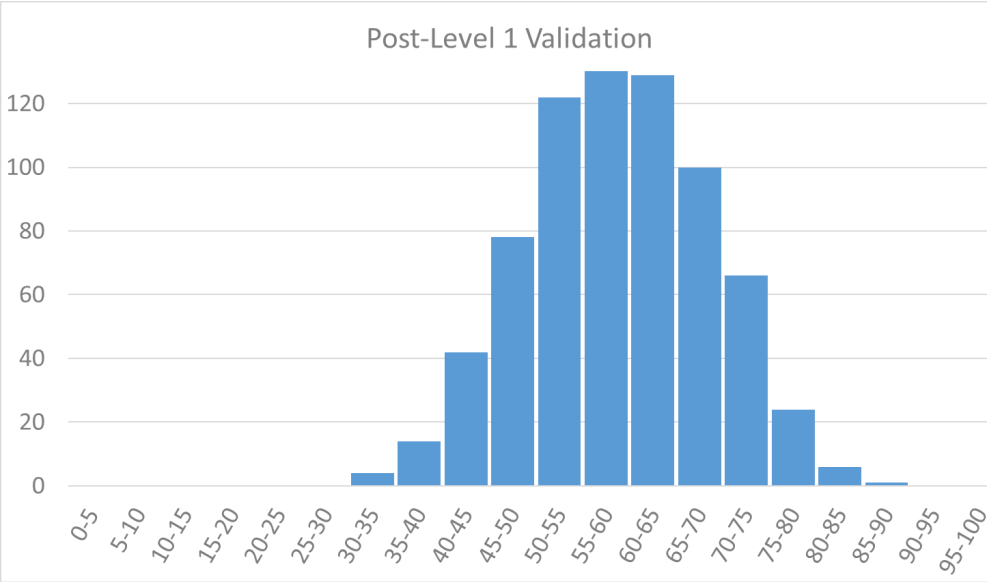
Changes to Data Validity Grades



Pre-Validated vs. Post-Validated Audits

Data Validity Distribution





Review

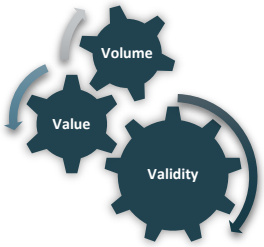
Annual Water Balance

Annual M36 water audit

Apparent & Real Loss volumes

Level 1 validation

baseline



Stage 1

Loss Profiling & Uncertainty

Advanced Validation
- Level 2 Analytics
- Level 3 Field Study
- Margins of Error

Apparent Loss Profile
- Theft
- Meter Inaccuracy
- Data Handling

Real Loss Profile
- Reported Leakage
- Unreported Leakage
- Background Leakage

technical analysis

Stage 2

Cost-Benefit & Targets

Costs of losses
- by subcomponent
- in aggregate
- wholesale & retail

Costs of intervention strategies

Program design

System-specific

economic analysis

Stage 3

Intervention

Leakage Management:
- Active Leak Detection
- Pressure Optimization
- Repair Time Reduction
- Network Renewal

Revenue Protection:
- Theft Mitigation
- Meter Optimization & Renewal
- Billing Data System Integrity
- Revenue Recovery

cost-effectiveness

Stage 4

Your Water Loss Team

Who should participate from your utility?

Supply & Operations

Customer Metering

Billing & Finance

Management

who is responsible for

supplying audit data?

submitting the audit?

coordinating schedules?

The Water Balance

1. Account for volumes…

<table>
<tr><td rowspan="6">WATER SUPPLIED</td><td rowspan="4">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="2">UNBILLED AUTHORIZED CONSUMPTION</td><td>UNBILLED METERED CONSUMPTION</td><td rowspan="4">$ $ $

NONREVENUE WATER

💧</td></tr>
<tr><td>UNBILLED UNMETERED CONSUMPTION</td></tr>
<tr><td rowspan="3">WATER LOSSES</td><td rowspan="2">$ $ $
APPARENT LOSSES
$ $ $</td><td>CUSTOMER METER INACCURACIES</td></tr>
<tr><td>UNAUTHORIZED CONSUMPTION</td></tr>
<tr><td colspan="2">💧 REAL LOSSES 💧</td><td>DATA HANDLING ERRORS</td></tr>
</table>

- *Mass balance – process of elimination*
- *Account for all water*
- *Accuracy matters!*

AWWA Free Water Audit Software – Instructions Worksheet

AWWA Free Water Audit Software v6.0

FWAS v6.0

This spreadsheet-based water audit tool is designed to help quantify and track water losses associated with water distribution systems and identify areas for improved efficiency and cost recovery. It provides a "top-down" summary water audit format and is not meant to take the place of a full-scale, comprehensive water audit format. Auditors are strongly encouraged to refer to the most current edition of AWWA M36 Manual for Water Audits for detailed guidance on the water auditing process and targeting loss reduction levels. This tool contains several separate worksheets. Sheets can be accessed using the tabs at the bottom of the screen, or by clicking the TOC links below.

Table of Contents (TOC)

AWWA Web Resources for Water Loss Control

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

Items referenced in the Free Water Audit Software v6.0 on the web:

- Data Grading Matrix v6.0
- Example Water Audit v6.0
- Water Audit Compiler v6.0
- AWWA Reports on Performance Indicators
- M36 Manual

Enter Basic Information

Name of Utility:	County Water Utility
Name of Contact Person:	John Smith, Manager
Email:	
Telephone | Ext.:	
City/Town/Municipality:	Anytown
State / Province:	
Country:	USA
Audit Preparation Date:	Nov 02 2022
Audit Year:	2021
Audit Year Label:	Calendar (Fiscal, Calendar, etc)
Audit Period Start Date:	Jan 01 2021
Audit Period End Date:	Dec 31 2021
Volume Reporting Units:	Million gallons (US)
Water System Structure:	Retail
Water Type:	Potable Water
System ID Number:	
Validator Name/ID:	
Validator Email:	
Estimated Total Population Served by Water Utility:	

Key of Input Acronyms

In order of appearance in the Worksheet

VOS	Volume from Own Sources
VOSEA	VOS Error Adjustment
WI	Water Imported
WIEA	WI Error Adjustment
WE	Water Exported
WEEA	WE Error Adjustment
BMAC	Billed Metered Authorized Consumption
BUAC	Billed Unmetered Authorized Consumption
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UUAC	Unbilled Unmetered Authorized Consumption
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CMI	Customer Metering Inaccuracies
UC	Unauthorized Consumption
Lm	Length of mains
Nc	Number of service connections
Lp	Average length of (private) customer service line
AOP	Average Operating Pressure
CRUC	Customer Retail Unit Charge
VPC	Variable Production Cost

Color Key User input | Calculated | Optional default

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

Guidance for the Interactive Data Grading

Use acronym buttons in IDG header to navigate among inputs. Acronym Key above. White = needs answers, orange = complete, clear = not required. Example below.

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

After clicking an acronym button, answer all visible questions in the order they're presented, choosing best-fit answer

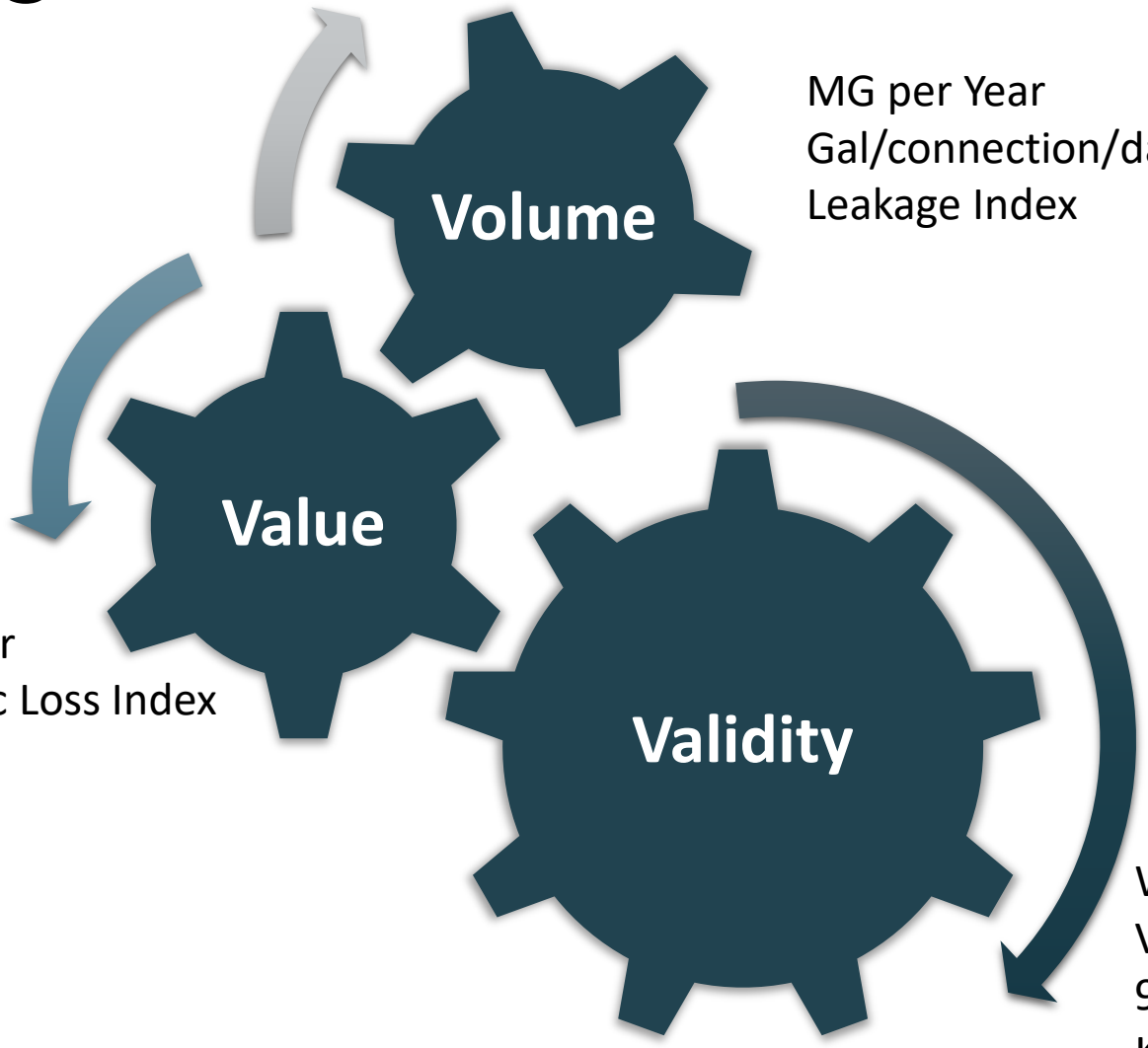
Grade will populate when all visible questions are complete for an input: 7

The limiting criteria will be labeled along the right. If only 1 limiting criterion is shown, improving on that criterion will achieve a higher data grade. If multiple limiting criteria are shown, improving on *each* limiting criterion is necessary to achieve a higher data grade. A complete inventory of data grading criteria is available in the Data Grading Matrix v6.0 (see web resources)

Limiting

If you have questions or comments regarding this software please contact us at: wlc@awwa.org

3-Vs



MG per Year
Gal/connection/day
Leakage Index

$ per Year
Economic Loss Index

Water Audit Data
Validity Score
95% Confidence Limits
Key Data Input Grades

What does Level 1 water audit validation do?

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- Identify/adjust any evident inaccuracies
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In meeting these goals, the Level 1 validation process results in:

- Data validity grades that reflect utility practices
- Identification of macro-level inaccuracies
- Recommendations for advanced validation activities

Next Steps

Establish Your Team

- Supply Metering
- Customer Metering
- Billing/Finance
- Management

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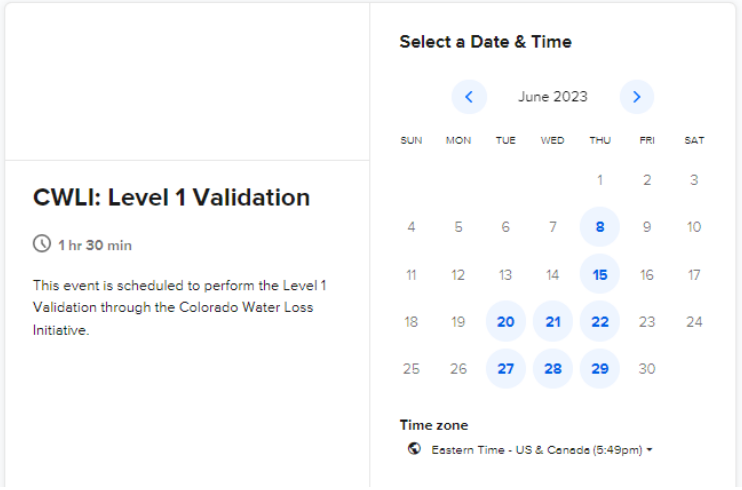
Colorado Water

Supply metering/Customer Metering/Billing/Management

Scheduling Your Session

Teleconference will be scheduled between **June and October** at

https://calendly.com/d/2hx-6pb-mbp/cwli-level-1-validation



Gather Data & Compile Water Audit

- **2022 Data**
- Data Request Sheet/Supporting Documentation
- Water Audit: Inputs & Data Validity Grades

Supporting Documentation

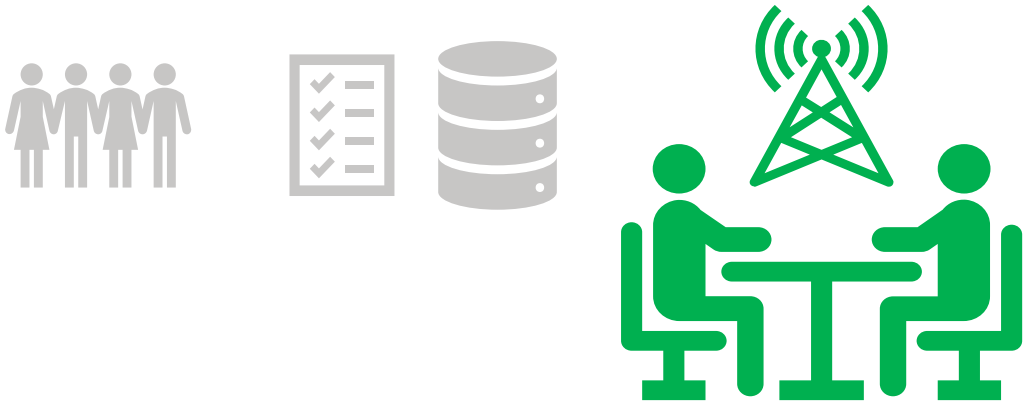
Required

- ☐ Completed **AWWA Free Water Audit Software** (Excel Spreadsheet)
- ☐ **Volume from Own Sources** broken down by month and finished water supply meter
- ☐ **Water Imported** broken down by month by meter
- ☐ **Water Exported** broken down by month by meter
- ☐ **Supply meter testing** and/or calibration documentation
- ☐ **Authorized Consumption** broken down by month and use type (e.g. charge status, water type, customer class)

Supporting Documentation

Supplemental

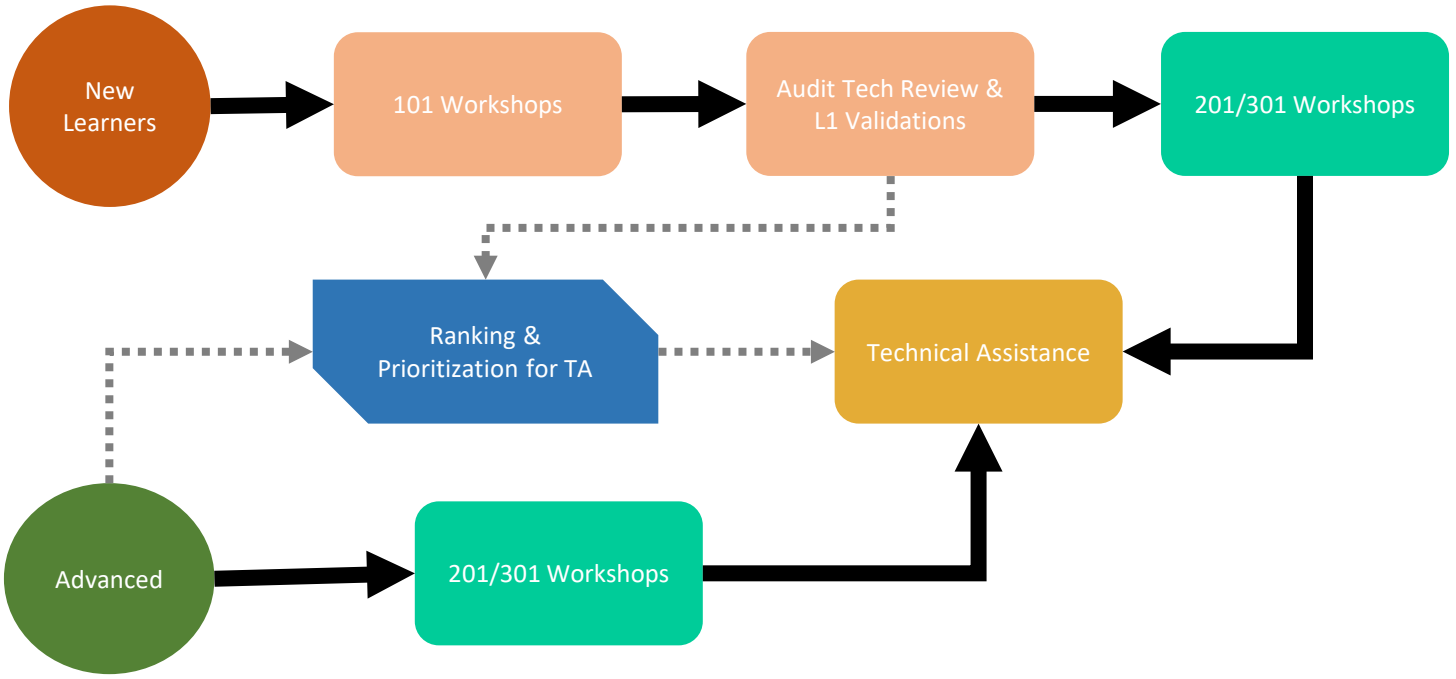
- ☐ **System schematic** showing at least locations of Own Source, Import, and Export meters
- ☐ **Customer Meter Inaccuracy** derivation
- ☐ **Average Operating Pressure** derivation
- ☐ **Customer Retail Unit Cost** derivation
- ☐ **Variable Production Cost** derivation



Level 1 Validation Session

- One-on-One validation session with your water audit validator

Phase 2 Design



Question & Answer

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Thank you!

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