This presentation premiered at WaterSmart Innovations

watersmartinnovations.com

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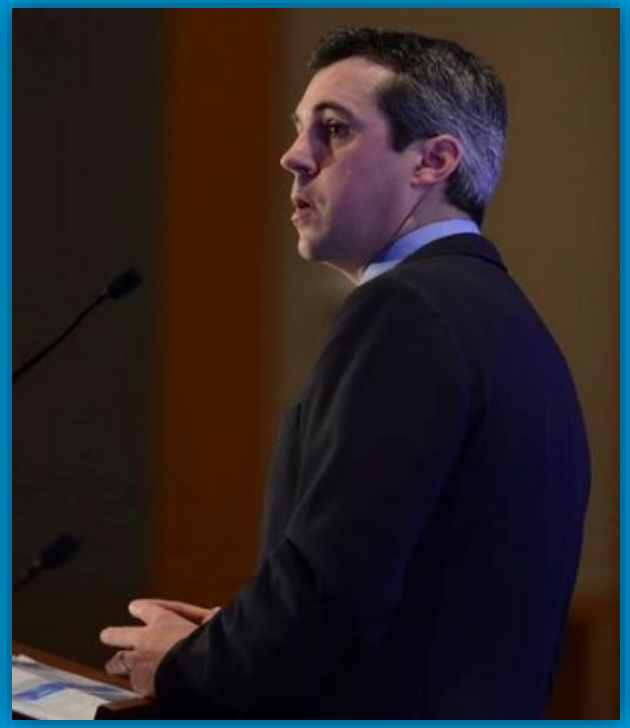
Stewardship Through Innovation



THE DATA GRADING MATRIX RELOADED:
FRESH INSIGHTS FROM AWWA'S WATER AUDITING TOOLS

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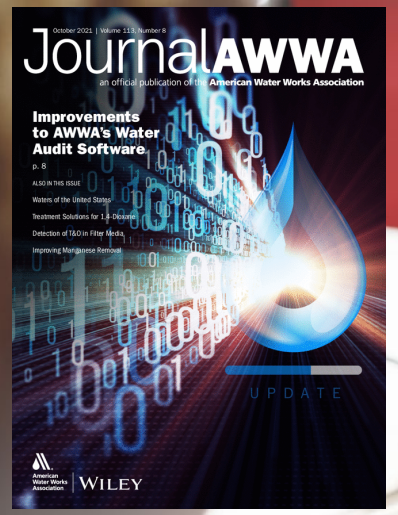
Chair / AWWA Water Loss Software Committee

Chair / North American Water Loss Conference

CFO, Director of Water Efficiency / Cavanaugh

25 YEARS 1995-2020 DELIVERING STEWARDSHIP THROUGH INNOVATION CAVANAUGH

watersmart INNOVATIONS



AWWA'S FREE WATER AUDIT SOFTWARE:

Updates and Improvements

Will Jernigan and David Sayers

Key Takeaways

AWWA's Water Loss Control Committee's Software Subcommittee has announced the release of a new version of the Free Water Audit Software.

The new release has nearly 1,000 updates and is intended to improve the user experience and increase the value of the software's data outputs.

With substantial enhancements that include interactive data grading and dashboard outputs for benchmarking, utilities that conduct top-down water audits are advised to use the newest software.

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COVER STORY Water Audit Software Enhancements

AWWA's Free Water Audit Software (FWAS) has been recognized in North America as the industry standard tool for conducting the top-down water audit following AWWA Manual M36, *Water Audits and Loss Control Programs*. FWAS was first published in 2006, with approximately 200 downloads during the first four years (Figure 1). The version before 2020 (v5.0) was released in 2014; it was downloaded more than 13,000 times, reflecting significant interest in the topic of water audits and water loss control in North America over the past decade (Sayers & Jernigan 2019).

Released in 2020, the latest FWAS (v6.0) was the culmination of approximately three years of development activity by AWWA's Water Loss Control Committee's (WLCC's) Software Subcommittee, which incorporated a review of nearly 1,000 user comments and included the dedicated development periods of testing.

Besides general enhancements, the Software Subcommittee established the following design objectives for FWAS v6.0:

- Accommodate a range of water system sizes, designs, and auditor experience levels.
- Include enough water audit parameters and system details to be effective, but streamline the program to be user-friendly and time-efficient.
- Remove subjective elements in the Data Grading Matrix.
- Minimize variability between FWAS v5.0 and FWAS v6.0 scores for the same input conditions.

Many decisions in the development of v6.0 came down to weighing different objectives and determining the best balance that would accurately serve the m

While nearly 1,000 updates were incorporated i v6.0, the following sections detail the most imp improvements, which are categorized as inputs grading, and outputs.

Input Enhancements

The major water balance principles and catego AWWA Manual M36 remain unchanged from p versions of the FWAS, but refinements were ma water audit Worksheet to make it easier to use promote consistency.

User Interface Updates

Acronyms and initialisms for 19 audit inputs ar rated into FWAS v6.0 to be efficient with text sp to encourage distinct recognition of each input associated water balance components or deriv formance indicators (KPIs). It is recognized tha nyms and initialisms will take some getting us this will come with experience, and they are all ideas or units commonly used in practice. A ke vided for reference on the software start page (

On the Worksheet, conventions for over- an under-registration on error adjustments are n made clear with drop-down selections. The ov and under-registration convention is now con across the Water Supplied inputs and the Cust Metering Inaccuracies input; a positive entry i required, followed by drop-down menu design shown in Figure 3. Prev FWAS v5.0, this conven inconsistently applied.

Also, on the Workshe Total Annual Operating been moved from a requ to an optional input. Th is no longer necessary fo lating KPIs, per the WL position (AWWA WLCC

Finally, a Blank Sheet provided and can be use whatever reason the use Anticipated uses includ ing calculations and any supporting documentat is not convenient to incl Notes tab.

Updates to Defaults

Previous defaults for Unl Unmetered Authorized

AWWA's Free Water Audit Software (FWAS) Release Timeline

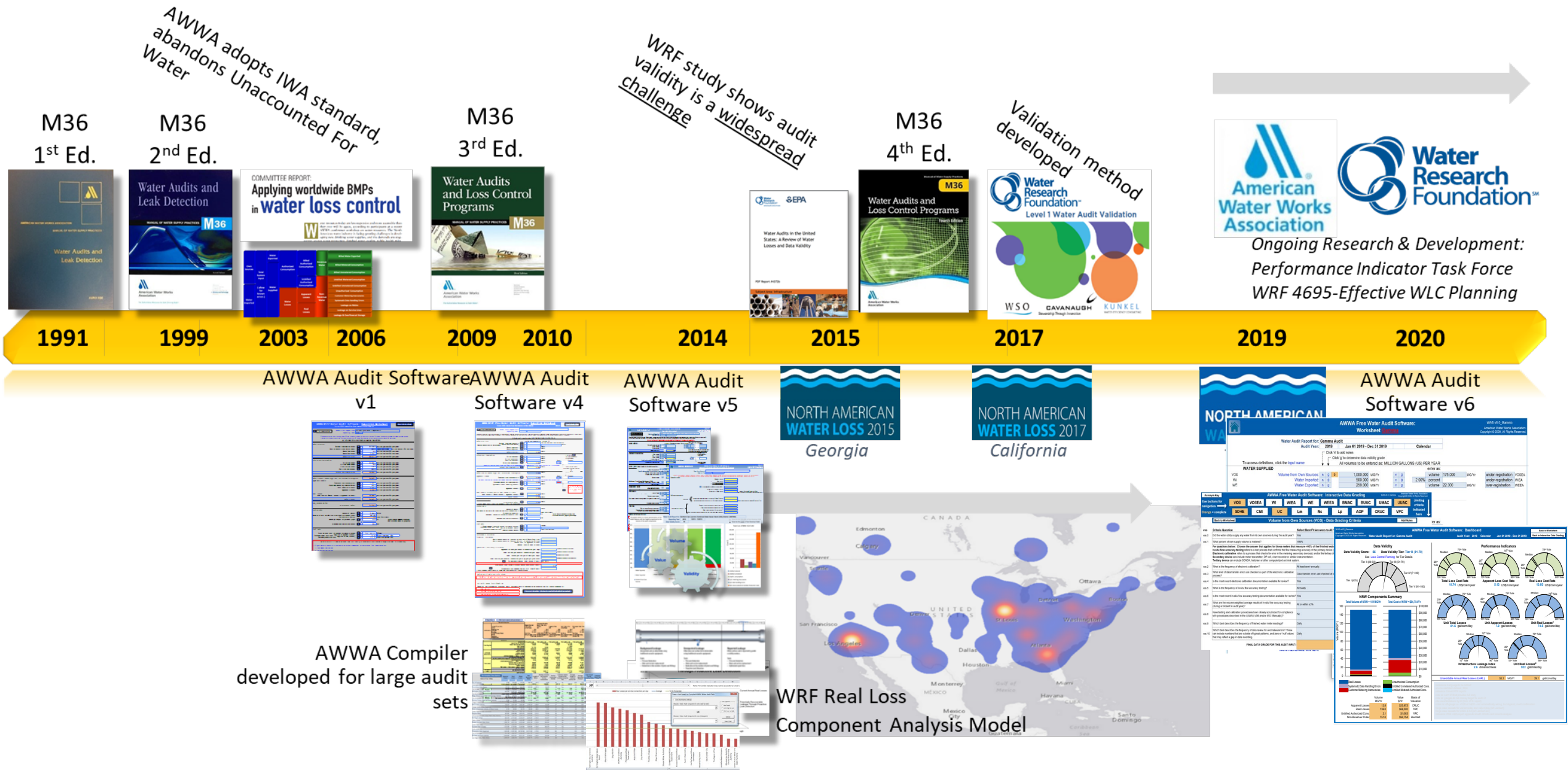
2006 2010 2014 2020

Figure 1

Figure 3

Figure 4

JOURNAL AWWA • OCTOBER 2021


M36
1st Ed.
M36
2nd Ed.
AWWA adopts IWA standard, abandons Unaccounted For Water
M36
3rd Ed.
WRF study shows audit validity is a widespread challenge
M36
4th Ed.
Validation method developed
Water Audits and Leak Detection
Water Audits and Leak Detection M36
COMMITTEE REPORT:
Applying worldwide BMPs in water loss control
Water Audits and Loss Control Programs M36
EPA
Water Audits in the United States: A Review of Water Losses and Data Validity
Water Audits and Loss Control Programs M36
Water Research Foundation
Level 1 Water Audit Validation
WSO
CAVANAUGH
KUNKEL
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
AWWA Audit Software v6
AWWA Compiler developed for large audit sets
WRF Real Loss Component Analysis Model

AWWA adopts IWA standard, abandons Unaccounted For Water

WRF study shows audit validity is a widespread challenge

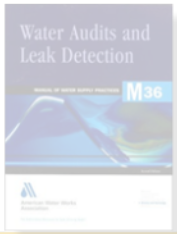
Validation method developed

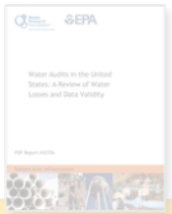
M36 1st Ed.

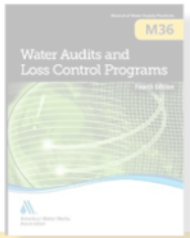
M36 2nd Ed.

M36 3rd Ed.

M36 4th Ed.







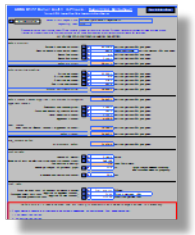
American Water Works Association

Water Research Foundation

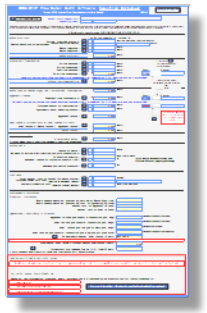
Ongoing Research & Development:
Performance Indicator Task Force
WRF 4695-Effective WLC Planning

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

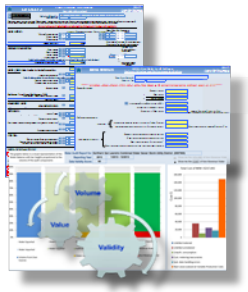
AWWA Audit Software v1



AWWA Audit Software v4



AWWA Audit Software v5

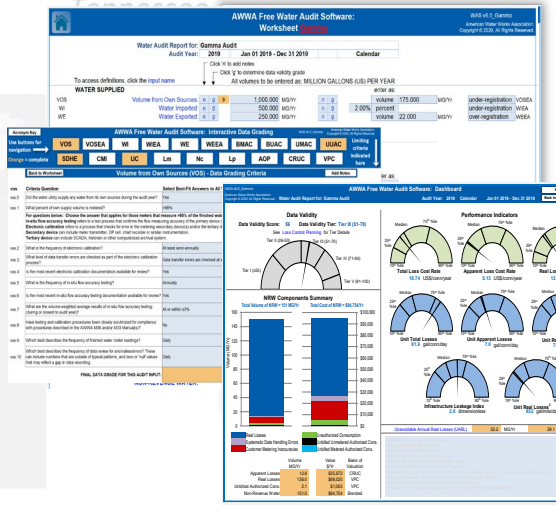


NORTH AMERICAN WATER LOSS 2015
Georgia

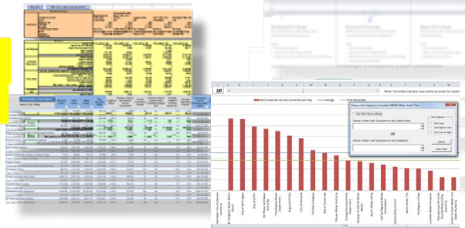
NORTH AMERICAN WATER LOSS 2017
California

NORTH AMERICAN WATER LOSS 2019

AWWA Audit Software v6

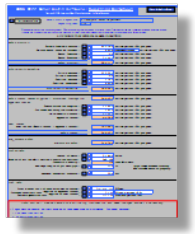


AWWA Compiler developed for large audit sets



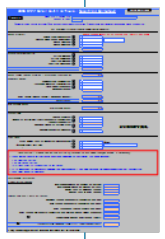
WRF Real Loss Component Analysis Model

FWAS v1



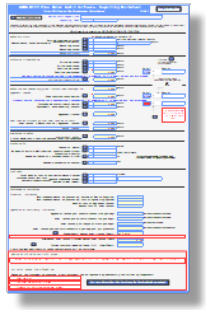
MG volumes only
Data grading:
either ‘measured’
or ‘estimated’

FWAS v2 – v3



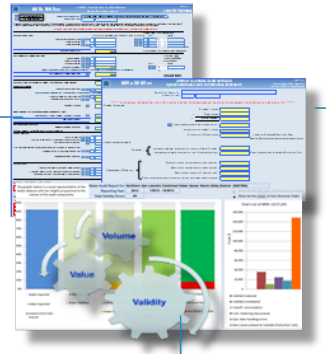
Megaliters added
Two financial performance indicators added (cost of real and apparent losses)
Acre-ft added
Example audits included
Two default values
Data checks / instant feedback added

FWAS v4



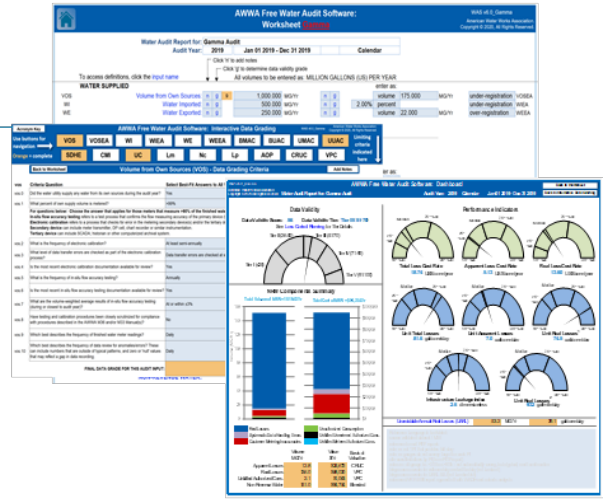
Data grading matrix (1-10)
Service connection diagram
French language version available

FWAS v5

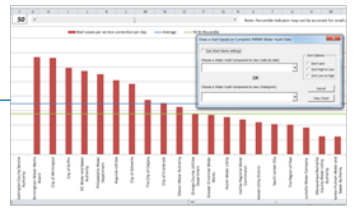


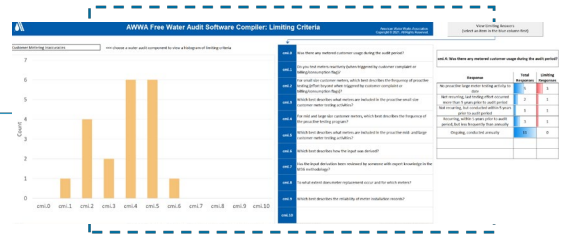
Separate data input/output tabs
Dashboard
Volume weighted data grading
Comments page
Meter error adjustment for all water supplied components

FWAS v6

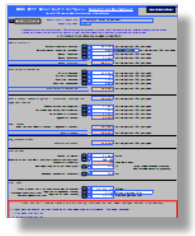


AWWA Compiler developed for large audit sets

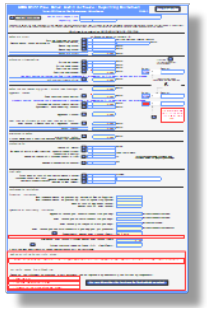




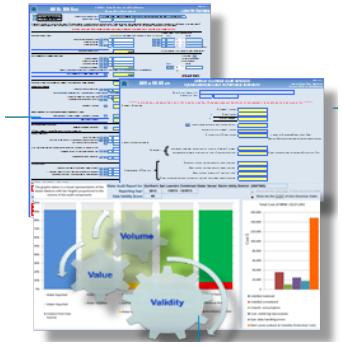
FWAS v1



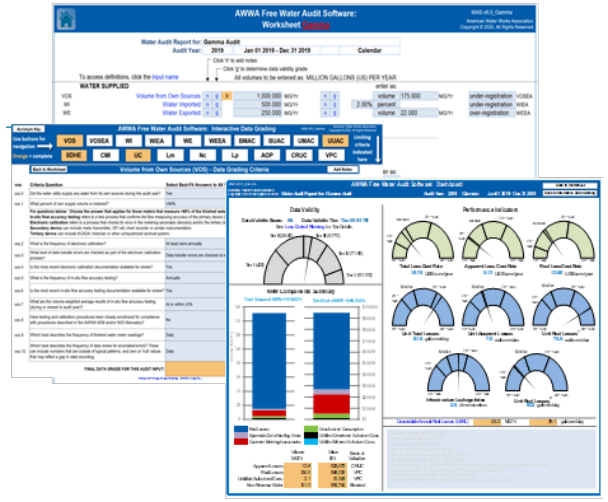
FWAS v4



FWAS v5

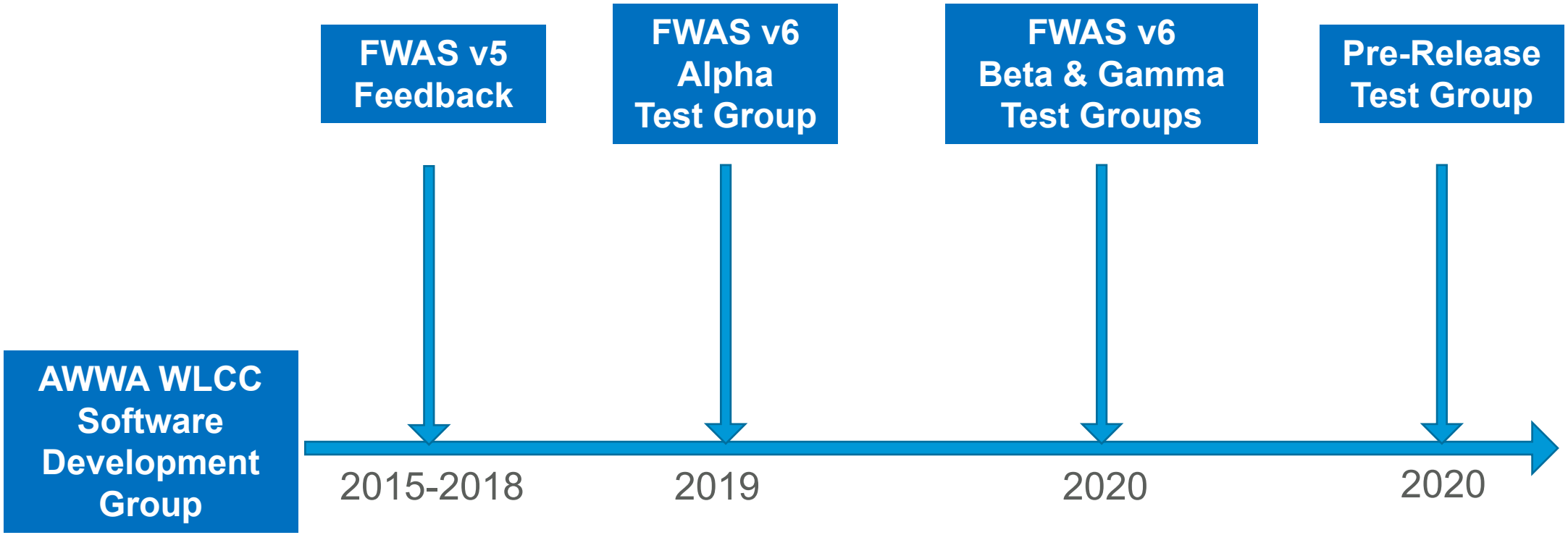


FWAS v6



Total Number of Water Systems in the US and Canada ~60,000

2006-2010	2010-2014	2014-2020	Last 10 months
200 downloads	2,000 downloads	13,000 downloads	3,000 downloads



World Water Loss Day
4th December

- Volunteer effort
- Large stakeholder team
- Utilities, consultants, regulators
- Multiple feedback loops
- Over 1,000 comments received to date related to v6 development

American Water Works Association
Dedicated to the World's Most Important Resource®

v6.0 Design Objectives

- **Accommodate a very wide range of water system setups**, including small to large, retail v wholesale, own supply v purchased supply, metered v unmetered, and many more parameters that can widely vary across the over 50,000 water systems in North America;
- **Accommodate a very wide range of user knowledge**, from first-time FWAS users to highly experienced water loss management practitioners;
- **Achieve sufficient technical detail and rigor** for tool effectiveness;
- **Achieve sufficient simplicity** for tool efficiency;
- **Minimize cognitive load** on the user interface for tool intuitiveness;
- **Maximize awareness of user for best-practices** through data grading questions;
- **Remove any Data Grading criteria subjectivity** or ambiguity that existed in FWAS v5.0;
- **Update Data Grading criteria questions** where needed to reflect best-practice or technological advancements;
- **Minimize inevitable variance** that will be observed **in total Data Validity Score** for any given audit, with same or similar input parameters, between FWAS v5.0 and FWAS v6.0;

v6.0 – What's New?

Worksheet

v5

Click to access definition
Click to add a comment

Water Audit Report for: V5 Example Audit
Reporting Year: 2019 1/2019 - 12/2019

Please enter data in the white cells below. Where available, metered values should be used; if metered values are unavailable please estimate a value. Indicate your confidence in the accuracy of the input data by grading each component (n/a or 1-10) using the drop-down list to the left of the input cell. Hover the mouse over the cell to obtain a description of the grades

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 utility meets or exceeds all criteria for that grade and all grades below it.

Master Meter and Supply Error Adjustments

WATER SUPPLIED <---------- Enter grading in column 'E' and 'J' ----------> Pcnt: Value:

Volume from own sources:	7	1,000.000	acre-ft/yr	8	1.00%			acre-ft/yr
Water imported:			acre-ft/yr					acre-ft/yr
Water exported:			acre-ft/yr					acre-ft/yr
WATER SUPPLIED:		**990.099**	acre-ft/yr					

Enter negative % or value for under-registration
Enter positive % or value for over-registration

AUTHORIZED CONSUMPTION

Click here: ? for help using option buttons below

Pcnt: Value:

Billed metered:	9	850.000	acre-ft/yr			
Billed unmetered:			acre-ft/yr			
Unbilled metered:			acre-ft/yr			
Unbilled unmetered:	5	15.000	acre-ft/yr		15.000	acre-ft/yr
AUTHORIZED CONSUMPTION:		**865.000**	acre-ft/yr			

Unbilled Unmetered volume entered is greater than the recommended default value

Use buttons to select percentage of water supplied **OR** value

WATER LOSSES (Water Supplied - Authorized Consumption) **125.099** acre-ft/yr

Pcnt: Value:

Apparent Losses

Unauthorized consumption:		2.475	acre-ft/yr	0.25%		acre-ft/yr

Default option selected for unauthorized consumption - a grading of 5 is applied but not displayed

Customer metering inaccuracies:	1	8.586	acre-ft/yr	1.00%		acre-ft/yr
Systematic data handling errors:	5	2.125	acre-ft/yr	0.25%		acre-ft/yr

Default option selected for Systematic data handling errors - a grading of 5 is applied but not displayed

Apparent Losses: **13.186** acre-ft/yr

Real Losses (Current Annual Real Losses or CARL)

Real Losses = Water Losses - Apparent Losses: **111.913** acre-ft/yr

WATER LOSSES: **125.099** acre-ft/yr

NON-REVENUE WATER

NON-REVENUE WATER: **140.099** acre-ft/yr

= Water Losses + Unbilled Metered + Unbilled Unmetered

SYSTEM DATA

Length of mains:	1	200.0	miles
Number of active AND inactive service connections:	5	5000	
Service connection density:		25	conn./mile main

Are customer meters typically located at the curbstop or property line? Yes

Average length of customer service line: (length of service line, beyond the property boundary, that is the responsibility of the utility)

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

Average operating pressure:	3	50.0	psi

COST DATA

Total annual cost of operating water system:	10	$2,500,000	$/Year
Customer retail unit cost (applied to Apparent Losses):	7	$2.00	$/100 cubic feet (ccf)
Variable production cost (applied to Real Losses):	3	$500.00	$/acre-ft

Use Customer Retail Unit Cost to value real losses

v6

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

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				
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

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)	Total Annual Operating Cost
VPC	Variable Production Cost:	n	g	3	$500.00	$/Million gallons	$2,500,000 $/yr (optional input)

Worksheet

v5

? Click to access definition
\+ Click to add a comment

Water Audit Report for: V5 Example Audit
Reporting Year: 2019 | 1/2019 - 12/2019

Please enter data in the white cells below. Where available, metered values should be used; if metered values are unavailable please estimate a value. Indicate your confidence in the accuracy of the input data by grading each component (n/a or 1-10) using the drop-down list to the left of the input cell. Hover the mouse over the cell to obtain a description of the grades

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 utility meets or exceeds all criteria for that grade and all grades below it.

WATER SUPPLIED

<---------- Enter grading in column 'E' and 'J' ---------->

Master Meter and Supply Error Adjustments

					Pcnt:	Value:	
Volume from own sources:	7	1,000.000	acre-ft/yr	8	1.00%		acre-ft/yr
Water imported:			acre-ft/yr				acre-ft/yr
Water exported:			acre-ft/yr				acre-ft/yr
WATER SUPPLIED:		**990.099**	acre-ft/yr				

Enter negative % or value for under-registration
Enter positive % or value for over-registration

v6

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					

Worksheet

v5

COST DATA

Total annual cost of operating water system:	+	?	10	$2,500,000	$/Year
Customer retail unit cost (applied to Apparent Losses):	+	?	7	$2.00	$/100 cubic feet (ccf)
Variable production cost (applied to Real Losses):	+	?	3	$500.00	$/acre-ft

☐ Use Customer Retail Unit Cost to value real losses

v6

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)

Worksheet

v5

WATER AUDIT DATA VALIDITY SCORE:

*** YOUR SCORE IS: 62 out of 100 ***

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

PRIORITY AREAS FOR ATTENTION:

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

1: Volume from own sources

2: Customer metering inaccuracies

3: Variable production cost (applied to Real Losses)

v6

WATER AUDIT DATA VALIDITY TIER:

*** The Water Audit Data Validity Score is in Tier III (51-70). 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: Customer Metering Inaccuracies (CMI)
3: Length of Mains (Lm)

KEY PERFORMANCE INDICATOR TARGETS:

OPTIONAL: User may enter targets for operational performance indicators below:

Unit Total Losses:	45.0	gal/conn/day
Unit Apparent Losses:	5.0	gal/conn/day
Unit Real Losses[A]:	40.0	gal/conn/day
Unit Real Losses[B]:	500	gal/mile/day
Infrastructure Leakage Index:	1.5	dimensionless

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

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 utility meets or exceeds all criteria for that grade and all grades below it.

Master Meter and Supply Error Adjustments

WATER SUPPLIED

<---------- Enter grading in column 'E' and 'J' ----------> Pcnt: Value:

Volume from own sources:	7	af/
Water imported:		af/
Water exported:		af/

WATER SUPPLIED:

AUTHORIZED CONSUMPTION

Billed metered:	9
Billed unmetered:	
Unbilled metered:	
Unbilled unmetered:	5

Unbilled Unmetered volume entered is greater t

AUTHORIZED CONSUMPTION: ?

n/a (not applicable). Select this grading only if the water utility purchases/imports all of its water resources (i.e. has no sources of its own)

1. Less than 25% of water production sources are metered, remaining sources are estimated. No regular meter accuracy testing or electronic calibration conducted.

2. 25% - 50% of treated water production sources are metered; other sources estimated. No regular meter accuracy testing or electronic calibration conducted.

3. Conditions between 2 and 4

4. 50% - 75% of treated water production sources are metered, other sources estimated. Occasional meter accuracy testing or electronic calibration conducted.

5. Conditions between 4 and 6

6. At least 75% of treated water production sources are metered, or at least 90% of the source flow is derived from metered sources. Meter accuracy testing and/or electronic calibration of related instrumentation is conducted annually. Less than 25% of tested meters are found outside of +/- 6% accuracy.

7. Conditions between 6 and 8

8. 100% of treated water production sources are metered, meter accuracy testing and electronic calibration of related instrumentation is conducted annually, less than 10% of meters are found outside of +/- 6% accuracy

9. Conditions between 8 and 10

10. 100% of treated water production sources are metered, meter accuracy testing and electronic calibration of related instrumentation is conducted semi-annually, with less than 10% found outside of +/- 3% accuracy. Procedures are reviewed by a third party knowledgeable in the M36 methodology.


presentation is over
It’s demo time.

SUMMARY OF MAJOR V6 IMPROVEMENTS

- **Interactive Data Grading**
  - Improved consistency, objectivity, transparency in data grade assignment for each input
- **Fighterjet Dashboard**
  - KPIs updated per AWWA 2020 Position
  - KPIs shown on gauge against industry ranges

ACKNOWLEDGEMENTS

Software Development Group

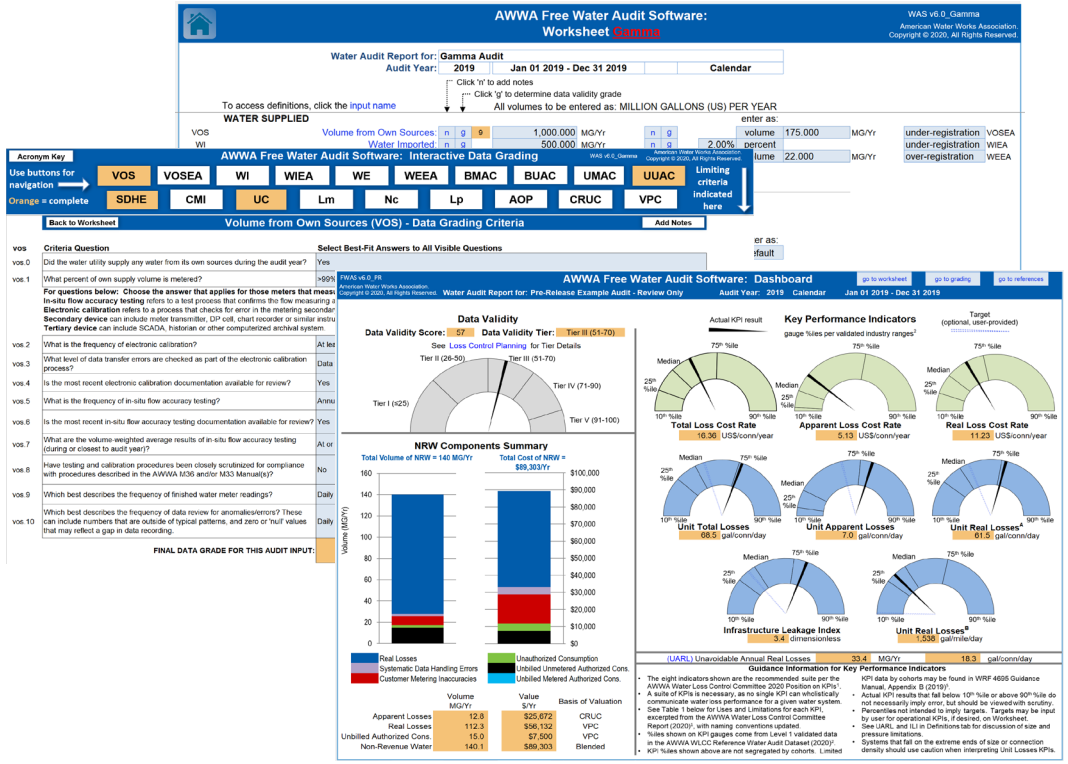
- Will Jernigan (Chair)
- David Sayers (Lead Developer)
- Kate Gasner
- Andrew Chastain-Howley
- George Kunkel

Alpha Test Group

- Drew Blackwell
- Heather Himmelberger
- Yannis Kachani
- Chris Leauber
- Sofia Marcus
- Brian Skeens
- Dan Strub
- Ken Brothers

Beta Testers

OFFICIAL RELEASE DATE



AWWA FWAS v6.0

World Water Loss Day

4th December

www.northamericanwaterloss.org

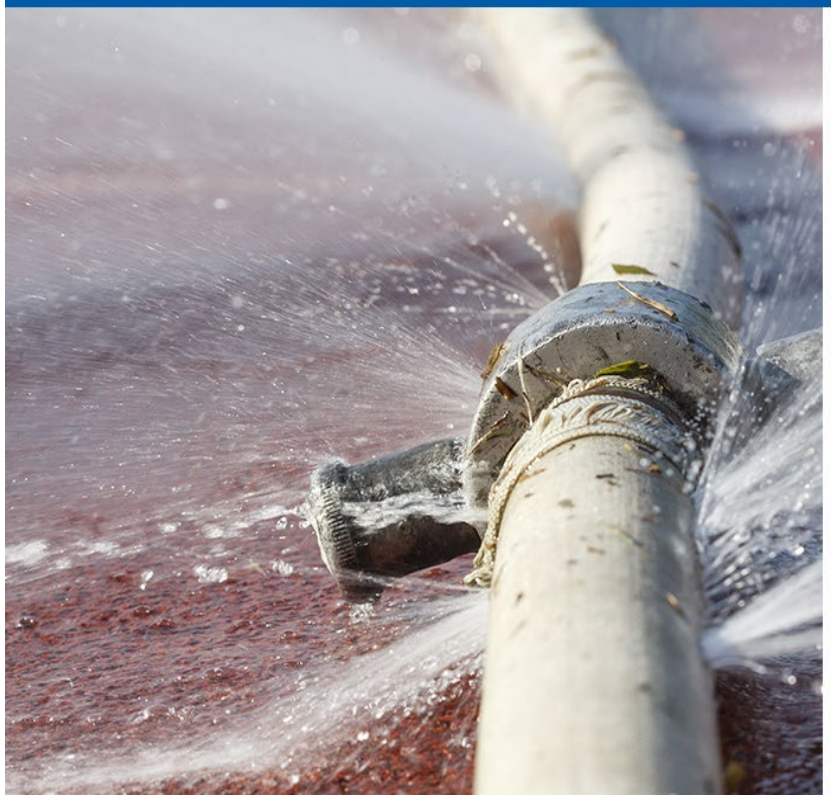
American Water Works Association

Dedicated to the World's Most Important Resource®

www.awwa.org/waterlosscontrol

NORTH AMERICAN WATER LOSS 2021

AUSTIN, TEXAS | DECEMBER 7-9



American Water Works Association

northamericanwaterloss.org

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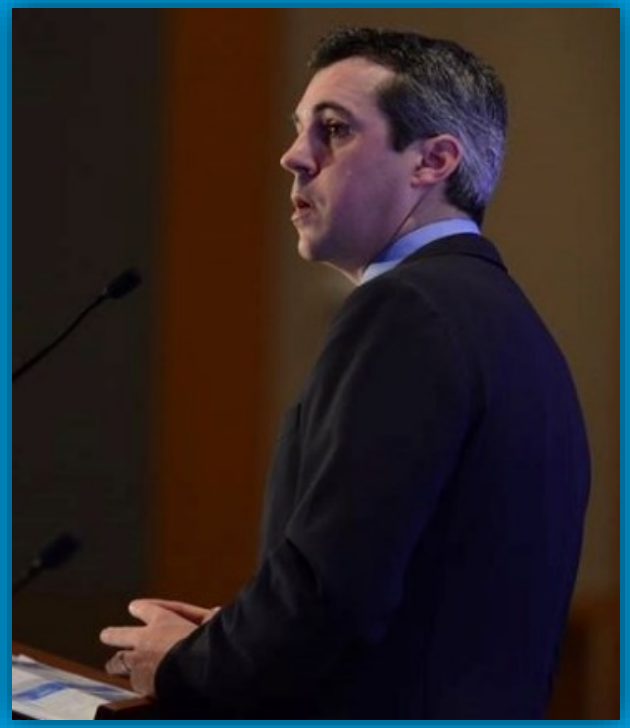

THE DATA GRADING MATRIX RELOADED:
FRESH INSIGHTS FROM AWWA'S WATER AUDITING TOOLS

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