



American Water Works
Association

Dedicated to the World's Most Important Resource®

CONTROLLING NON-REVENUE WATER IN DRINKING WATER UTILITIES

COURSE 5

***KEEPING AN EFFECTIVE NON-REVENUE
WATER MANAGEMENT PROGRAM GOING***



COURSE 5 LEARNING OBJECTIVES

As a result of this course, you will be able to:

Demonstrate	how Non-revenue Water will rise unless action is taken to contain it
Recall	that the water audit allows you to track your loss volumes and costs each year
Assess	Non-revenue Water levels and system conditions each year to set priorities
Identify	 technologies and methods that are effective in addressing losses in your system
Envision	your system 5-10 years from now, and how you would like to see the system operate then
Execute	your planned loss control activities, monitor progress, and adjust your actions as needed if losses remain excessive



ACKNOWLEDGMENTS

Project Contractor

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This eLearning module has been developed, reviewed, and approved by AWWA Staff. Thanks to contributing authors and the AWWA development team



Project Funding

This eLearning course was funded by AWWA. Thanks to contributing authors and the AWWA development team

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Course 5

Keeping an Effective Non-revenue Water Management Program Going

Course Agenda

Module Number	
1	Controlling Losses Never Ends: Planning, Budgeting, and Implementing the Program
2	Sustaining the Program: Staying Proactive for the Long-term Future
3	Course 5 Summary





MODULE 1

Controlling Losses Never Ends: Planning, Budgeting, and Implementing the Program



Module 1

Controlling Losses Never Ends: Planning, Budgeting, and Implementing the Program

Agenda

A. Containing Losses for the Long-term

B. Using Water Audit Results to Guide the Process

C. Planning and Budgeting

C. Implementing a Sustainable Program

E. Integrate the NRW Program with an Asset Management Program



Learning Objectives



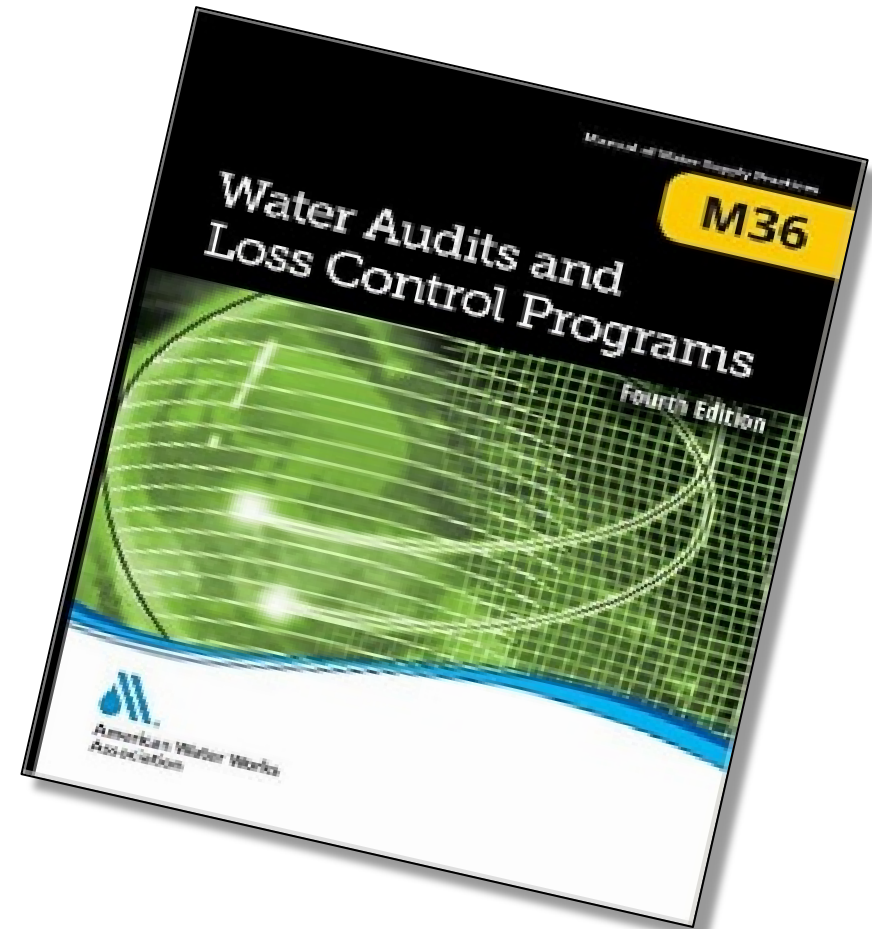
As a result of this module participants should be able to:

1. Explain the importance of ongoing loss control 
2. Formulate the key loss control activities and plan for their implementation
3. Organize the steps to implement the program and sustain it for the long-term



A. Containing Losses for the Long-term

*The AWWA M36 Manual: **Water Audits and Loss Control Programs** covers it all!*



AWWA's M36 Manual provides detailed guidance on water audits and Non-revenue Water management



A. Containing Losses Long-term

Without activities to contain it, Non-revenue Water will increase over time!



Water is under pressure and always trying to escape the pipeline that contains it – pipe defects and stresses of the pipe environment are always creating new leaks

Mechanical meters eventually wear and lose accuracy



Positive displacement, nutating disc meter
Source: Johnson Controls

Meter taken by unknown persons and replaced with a straight pipe or "jumper"



Water meters taken and replaced with a straight pipe represent unauthorized consumption that can occur in any water utility



A. Containing Losses for the Long-term – **KNOWLEDGE CHECK**

True or False: Once you have decreased non-revenue water to acceptable levels, you don't have to continue your loss control activities?

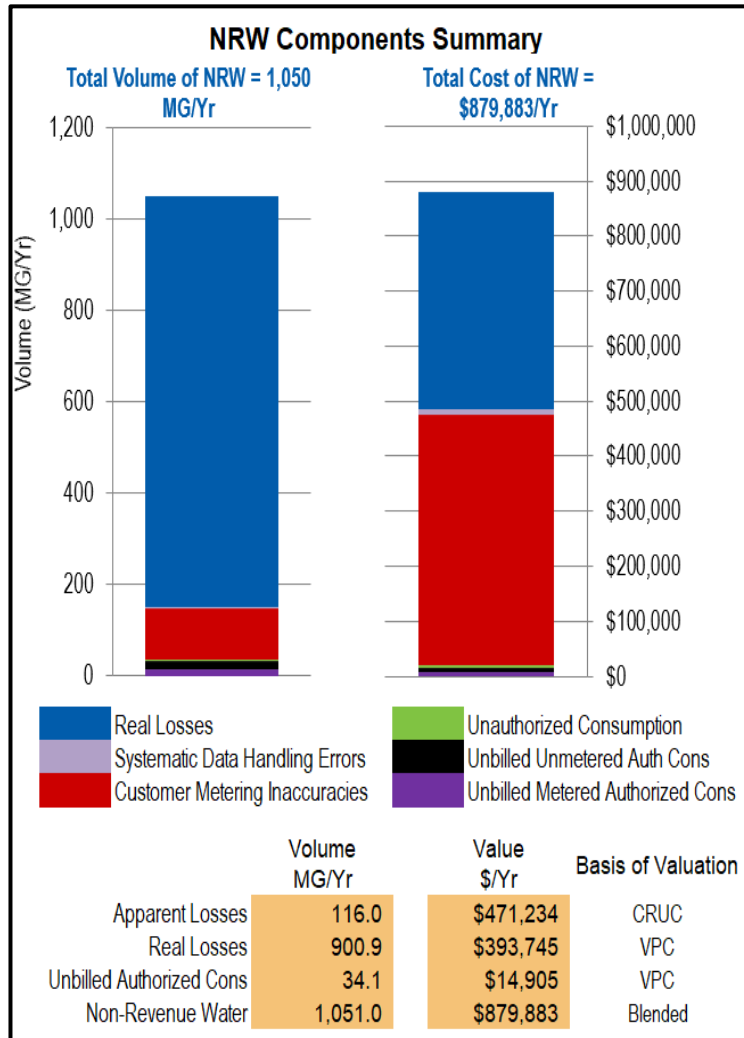
TRUE

FALSE

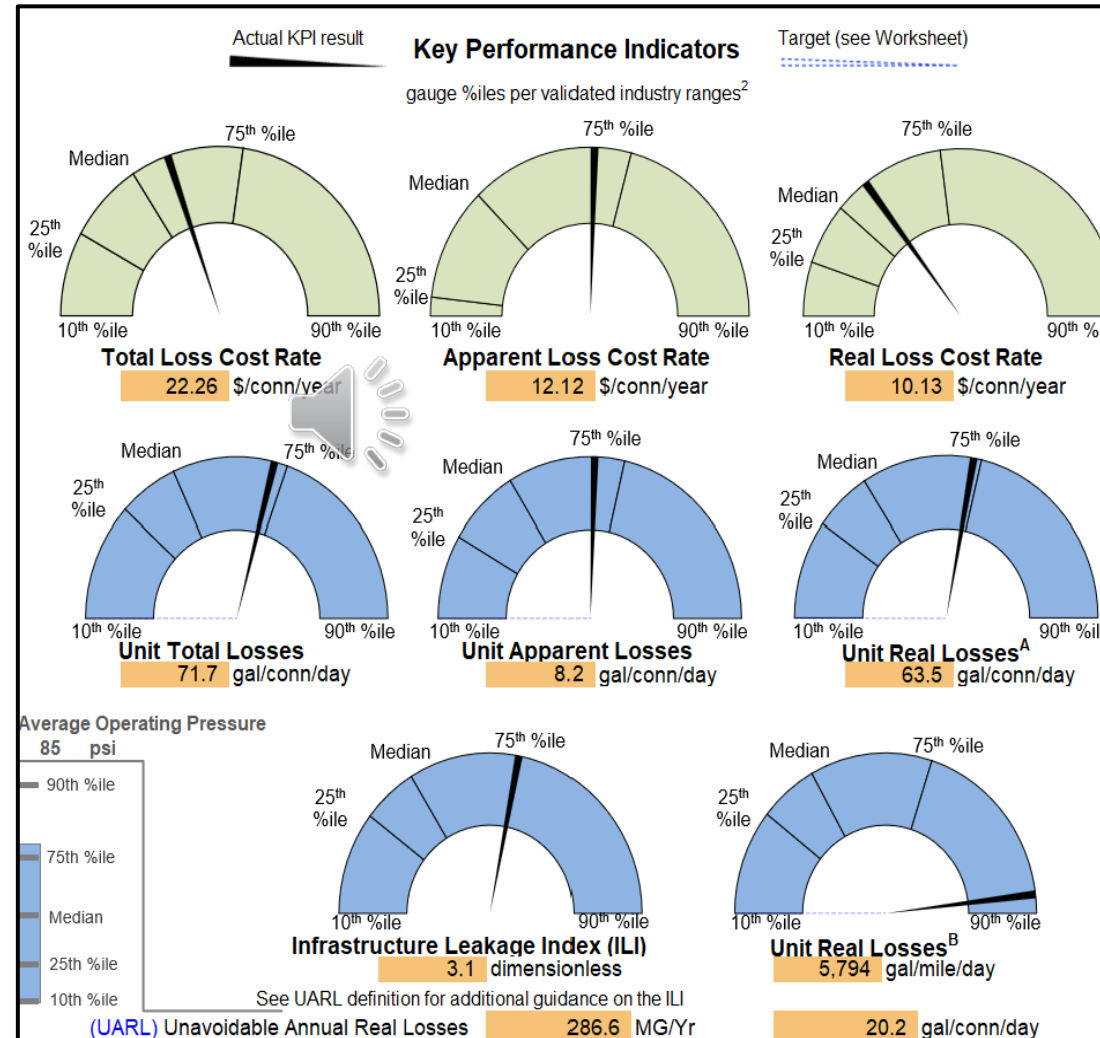


B. Using Water Audit Results to Guide the Process

Water Audit findings for example “Jones Township Water Authority”



Loss Volumes and Costs



Performance Indicators

Excerpts from
the Dashboard
Worksheet for
Jones Township
Water Authority
(JTWA)



WARD Percentile Values

- The table lists individual percentile values from the WARD
- The table also includes percentile values for the Customer Retail Unit Charge (CRUC) and the Variable Production Cost (VPC)

B. Using Water Audit Results to Guide the Process

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

B. Using Water Audit Results to Guide the Process

Apparent Losses from the JTWA Water Audit

Apparent Losses

Systematic Data Handling Errors:	n	g	2	2.742	MG/Yr
Customer Metering Inaccuracies:	n	g	4	111.703	MG/Yr
Unauthorized Consumption:	n	g	8	1.567	MG/Yr

Apparent Losses: 116.012 MG/Yr

choose entry option:

	custom	2.742	MG/Yr
3.50%	percent		
	custom	1.567	MG/Yr

under-registration

Custom values entered for Systematic Data Handling Errors and Unauthorized Consumption, both of which are lower than the volume that would be calculated if the default value were used

Customer Metering Inaccuracies were quantified at 3.50% under-registration, based upon meter accuracy test results.

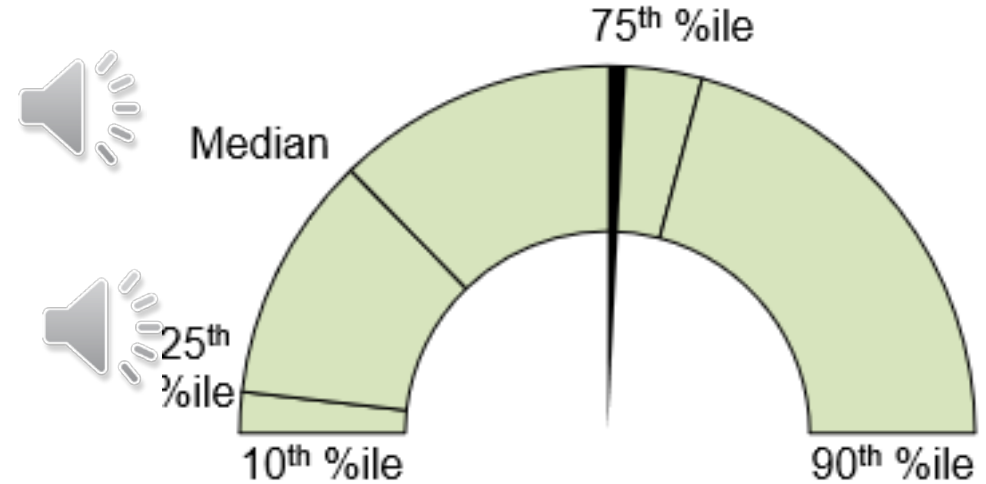


B. Using Water Audit Results to Guide the Process

JTWA APPARENT LOSS ASSESSMENT

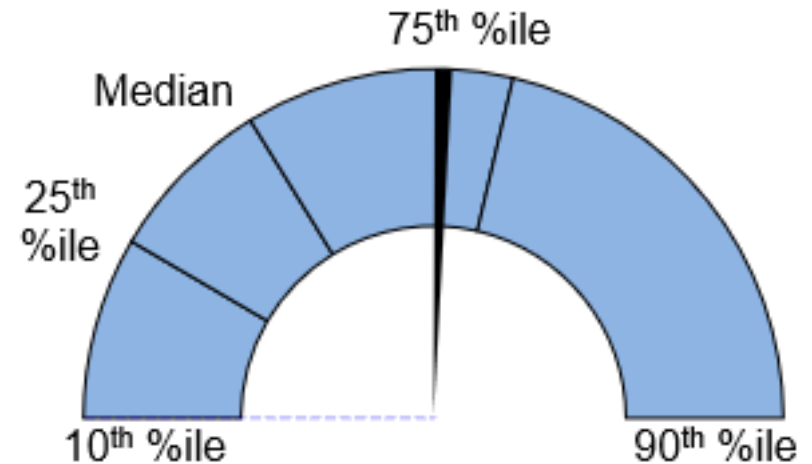
- 💧 Apparent Loss volume: 116.012 MG
- 💧 Apparent Loss cost impact: \$471,234
- 💧 CRUC = \$4.08 per 1,000 gallons, lower than the WARD median value of \$4.40 per 1,000 gallons
- 💧 Apparent Loss Cost Rate = \$12.12 per service connection per year, a high value almost as high as the WARD 75th percentile value
- 💧 Unit Apparent Loss rate = 8.20 gal/conn/day, also very close to the WARD 75th percentile value

Apparent Losses	116.0	\$471,234
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Apparent Loss Cost Rate

12.12 \$/conn/year



Unit Apparent Losses

8.2 gal/conn/day

B. Using Water Audit Results to Guide the Process

Real (Leakage) Losses from the JTWA Water Audit

Apparent Losses

Systematic Data Handling Errors:	n	g	2	2.742	MG/Yr
Customer Metering Inaccuracies:	n	g	4	111.703	MG/Yr
Unauthorized Consumption:	n	g	8	1.567	MG/Yr
Apparent Losses:				116.012	MG/Yr

choose entry option:

	custom	2.742	MG/Yr
3.50%	percent		
	custom	1.567	MG/Yr

under-registration

Real Losses

Real Losses: 900.873 MG/Yr

WATER LOSSES: 1,016.886 MG/Yr

NON-REVENUE WATER

NON-REVENUE WATER: 1,050.987 MG/Yr

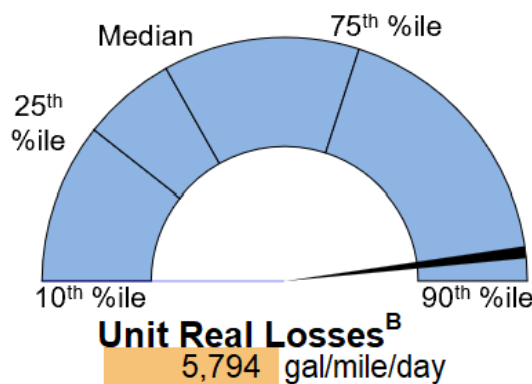
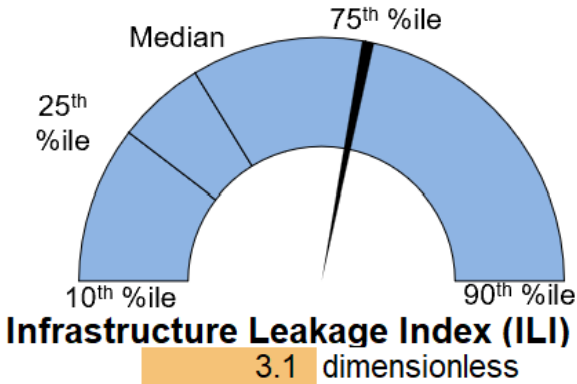
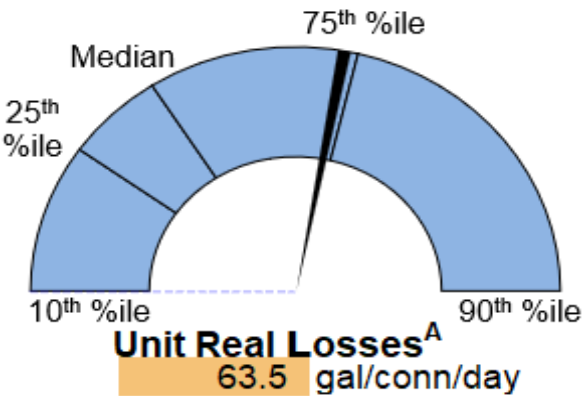
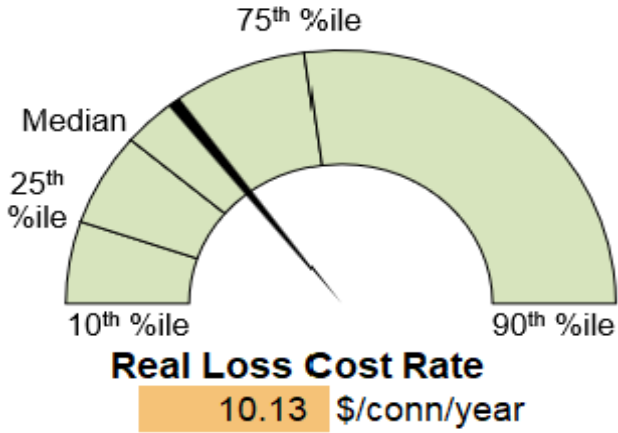
Recall that the Real Loss volume is calculated as a “catch-all” quantity, or the amount of water losses remaining after the Apparent Losses volume is subtracted from the Water Losses volume.



B. Using Water Audit Results to Guide the Process

- Real Loss volume: 900.9 MG
- Real Loss cost impact: \$393,745
- VPC = \$437.07 per MG, modestly lower than the WARD median value of \$529.07 per MG
- Real Loss Cost Rate = \$10.13 per service connection per year, which is modestly higher than the median WARD value
- Unit Real Loss rate = 63.5 gal/conn/day, which is almost to the 75th percentile WARD value

Real Losses	900.9	\$393,745
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B. Using Water Audit Results to Guide the Process

Summarizing JTWA's Attributes and Performance Indicators

Attribute/ Indicator	JTWA Value	WARD Median Value	Assessment of JTWA NRW Standing
Apparent Lost Cost Rate	\$12.12/conn/yr	\$6.15/conn/yr	Apparent Loss Cost Rate is high
Unit Apparent Loss	8.2 gal/conn/day	5.3 gal/conn/day	Apparent loss rate is high
Customer Retail Unit Cost (CRUC)	\$4.08/1,000 gallons	\$4.40/1,000 gallons	CRUC is low, tempering the cost impact of apparent losses
Apparent Loss Cost	\$471,234		<i>Notable uncaptured revenue exists; it's worth reducing apparent losses</i>
Real Lost Cost Rate	\$10.13/conn/yr	\$7.95/conn/yr	Real Loss Cost Rate is high
Unit Real Loss	63.5 gal/conn/day	36.8 gal/conn/day	Real loss rate is high
Variable Production Cost (VPC)	\$437.07 per MG	\$529.07 per MG	VPC is low, tempering the cost of leakage
Real Loss Cost	\$393,745		<i>Moderately high leakage warrants reduction, but only a modest amount will be cost-effective since VPC is low</i>



B. Using Water Audit Results to Guide the Process

Loss Control Priorities for JTWA

Assumption: 50% of Apparent Loss costs are recoverable

First Priority: strive to reduce Apparent Losses

- Invest up to \$236,000 for customer metering improvements

Apparent Losses

					choose entry option:			
Systematic Data Handling Errors:	n	g	2	2.742	MG/Yr	custom	2.742	MG/Yr
Customer Metering Inaccuracies:	n	g	4	111.703	MG/Yr	3.50%	percent	under-registration
Unauthorized Consumption:	n	g	8	1.567	MG/Yr	custom	1.567	MG/Yr
Apparent Losses:				116.012	MG/Yr			



B. Using Water Audit Results to Guide the Process

Loss Control Priorities for JTWA

Assumption: 50% of leakage costs are recoverable

Medium Priority: Make modest reduction in leakage

- *Invest up to \$197,000 on further leakage control*
- *Launch or increase the frequency of acoustic leak detection*



B. Using Water Audit Results to Guide the Process – **KNOWLEDGE CHECK**

True or False: It can be useful for water utilities to compare their key water audit results with validated water audit datasets

TRUE

FALSE



B. Using Water Audit Results to Guide the Process

Summary: JTWA Non-revenue Water Assessment

The JTWA water audit gives priority for both Apparent & Real loss reduction



**Invest up to
\$236,000 on
replacement
customer meters to
reduce Apparent
Losses**

**Invest up to
\$197,000 on
increased acoustic
leak detection**



B. Using Water Audit Results to Guide the Process – **KNOWLEDGE CHECK**

Which of the below steps is not a reliable parameter to use to assess Non-revenue Water levels and set loss reduction targets?

- a. Apparent Loss Rate**
- b. Variable Production Cost, VPC**
- c. Unaccounted-for water percentage**
- d. Real Loss Rate**



C. Planning and Budgeting

Key Planning Concepts

NRW control is always needed



NRW control activities should be ongoing

NRW control activities should be in each year's budget

Take a long-term, multi-year outlook; think 5-10 years ahead



C. Planning and Budgeting

Five Year NRW Plan and Budget for Jones Township Water Authority

JONES TOWNSHIP WATER AUTHORITY - NON-REVENUE WATER MANAGEMENT ACTIVITY TIMELINE																											
			Complete		Scheduled																						
ACTIVITY		ASSIGNED TO		START	END	FREQUENCY	COST	2022				2023				2024				2025				2026			
								Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1. Test (4) production flowmeters		ABC Testing Service, Inc.		March 1	March 3	Annual	\$8,000																				
2. Test 200 customer meters		ABC Testing Service, Inc.		July 1	Aug 1	Annual	\$12,000																				
3. Replace 500 customer meters		JTWA Staff		January 1	Dec 31	Annual	\$7,500																				
4. Full system acoustic leak detection survey		Leak Detection Services, LLC		April 1	Dec 31	2022	\$170,400																				
5. Full system acoustic leak detection survey		JTWA Staff		April 1	Sept 30	Every other year after 2022	\$170,400																				
6. Billing system analysis		Financial Accountants, Inc.		Sept 1	Nov 30	Periodic (5 year)	\$50,000																				
7. Install District Metered Area (DMA) with pressure management in high pressure zone		Consulting engineer, equipment supplier, inhouse staff		July 1	Dec 31	Special Project	\$20,000																				
8. Customer meter replacement project and Advanced Metering Infrastructure (AMI)		Consulting engineer, meter/AMI supplier/installer		Jan 1	Dec 31	Periodic (20 year)	\$1,800,000																				
							Annual Cost	\$277,900				\$277,900				\$157,500				\$297,900				\$1,808,000			

Gantt Chart for JTWA



C. Planning and Budgeting

Five Year NRW Plan and Budget for Jones Township Water Authority

Budget for Apparent and Real Loss Control Activities

Budget Year	2022	2023	2024	2025	2026
Apparent Loss Control	\$107,500	\$107,500	\$157,500	\$107,500	\$1,808,000
Real Loss Control	\$170,400	\$170,400	\$ 0	\$190,400	\$ 0
Total	\$277,900	\$277,900	\$157,500	\$297,900	\$1,808,000

Gantt Chart Summary Budget Numbers for JTWA



C. Planning and Budgeting

Important Planning Steps

PLANNING THE NRW MANAGEMENT PROGRAM

1. Share the water audit results and priorities for loss control with utility leadership and staff 
2. Set initial loss reduction targets and timelines, and establish a budget to provide adequate funding
3. Assign responsibility for tasks to motivated staff members
4. Investigate the methods, technologies, equipment, and services to determine the best ones to use for loss control



C. Planning and Budgeting

PLANNING THE NRW MANAGEMENT PROGRAM

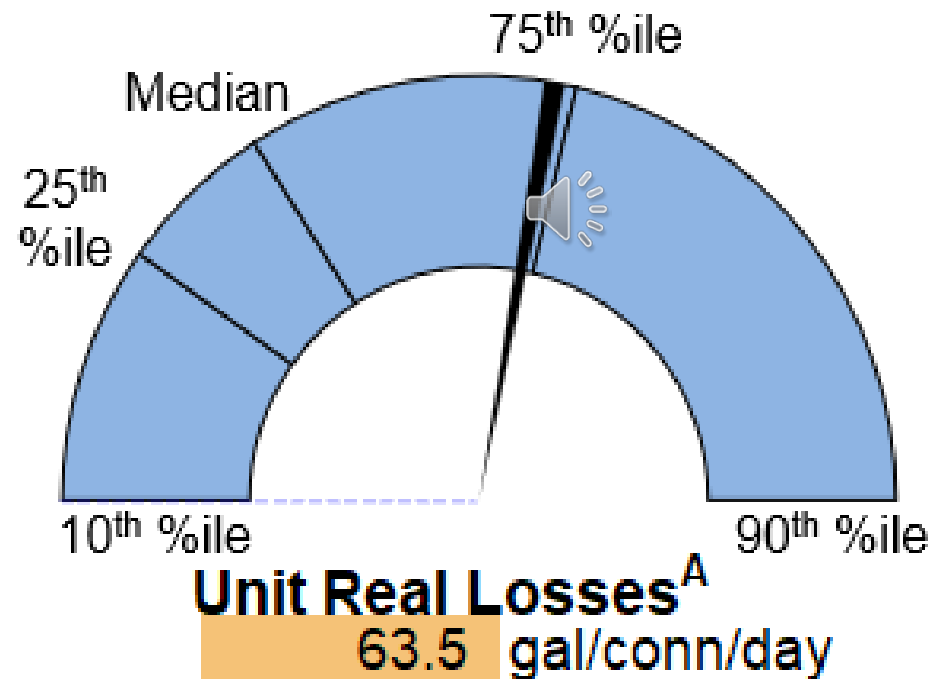
2. Set initial loss reduction targets and timelines, and establish a budget to provide adequate funding

WARD Percentile Values

Median: 36.8 g/c/d

75th percentile: 66.4 g/c/d

JTWA Leakage Rate is 63.5 g/c/d, is high, almost reaching the WARD 75th percentile value



Targeting Leakage Reduction

- ◆ Current rate: 63.5 g/c/d
- ◆ Set a realistic long-term target. Ex: slightly above the WARD median value of 36.8 g/c/d – say 40.00 g/c/d within 5 years
- ◆ Projected yearly levels to target
 - Year 1 (2023): 61 g/c/d
 - Year 2 (2024): 51 g/c/d
 - Year 3 (2025): 49 g/c/d
 - Year 4 (2026): 42 g/c/d
 - Year 5 (2027): 40 g/c/d



C. Planning and Budgeting – **KNOWLEDGE CHECK**

Which of the below is the name of a chart used to plan activities in a timeline of weeks, months, or years?

- a. Water Balance**
- b. Gantt Chart**
- c. Water Audit**
- d. Pump Curve**



D. Implementing a Sustainable Program

Important Implementation Steps

LAUNCHING THE NRW MANAGEMENT PROGRAM

- 1. Launch the loss control activities  according to the schedule**
- 2. Obtain regular progress reports – identify challenges and obstacles**
- 3. Integrate loss control activities with other utility functions**
- 4. Celebrate the program successes**



D. Implementing a Sustainable Program – KNOWLEDGE CHECK

Which of the below is the best way to get support from persons in your water utility for the Non-revenue Water Management Program?

- a. Direct your best workers to conduct more leak detection work on top of their regularly assigned duties**
- b. Share the water audit results and proposed loss reduction priorities with the Board of Directors and utility staff**
- c. Agree to purchase new water meters for all of your customers before getting approval from the Board of Directors**



E. Integrate the NRW Program with an Asset Management Program

Proper Asset Management of drinking water infrastructure includes:

1. Having an accurate inventory of infrastructure assets
2. Evaluating the condition of the infrastructure
 - Meter accuracy testing evaluates production flowmeters & customer meters
 - Data on leaks and water main breaks provide insight to piping condition
3. Creating a plan for maintenance and renewal of assets



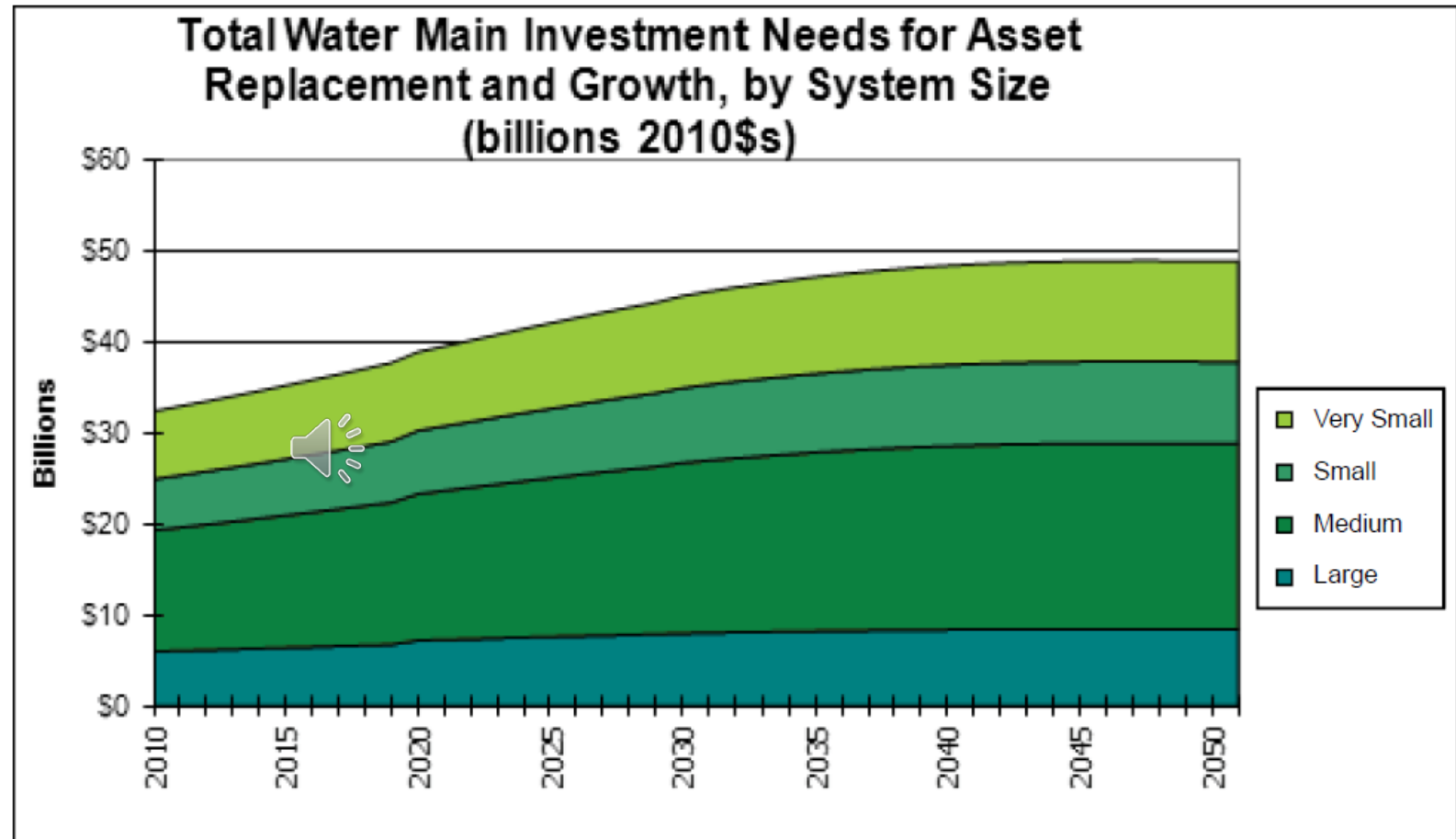
E. Integrate the NRW Program with an AM Program

Using advanced leak detection and pipe condition assessment gives a basis for planning pipe rehabilitation or replacement



E. Integrate the NRW Program with an AM Program

- 💧 **Leak/Break data gives insight to pipe replacement needs**
- 💧 **Assists long-term planning**



Source: AWWA "Buried No Longer" Report

E. Integrate the NRW Program with an AM Program – KNOWLEDGE CHECK

Which of the below is not part of the features of a good Asset Management Program?

- 1. Having an accurate inventory of infrastructure assets**
- 2. Relying on your infrastructure assets to last forever**
- 3. Having a plan for maintenance and renewal of assets**
- 4. Evaluating the condition of assets**



Module 1 Summary

Left unchecked, water and revenue losses will continue to rise and water utilities should compile the water audit to know their loss levels and cost impacts each year

Water utilities should include Non-revenue Water Management in their long-term planning and budget for activities to control losses to economic levels

Be sure to assign responsibility to motivated staff and routinely track your progress in managing Non-revenue Water

Now on to Module 2 which talks about the ways to sustain your NRW management for the long-term





MODULE 2

Sustaining the Program: Staying Proactive for the Long-term Future



Module 2

Sustaining the Program: Staying Proactive for the Long-term Future

Agenda

A. Tracking Your Progress in  Controlling Non-revenue Water

B. Making Adjustments as Needed

C. Tips for Continued Progress



Learning Objectives



As a result of this module participants should be able to:

1. Recite the ways  to track performance
2. Recognize when loss reduction is less than expected and how to adjust your activities
3. Identify how to obtain additional information and tips on new methods and technologies



A. Tracking Your Progress in Controlling Non-revenue Water

Steps for Tracking Progress

Compile the water audit every year as a standard business practice



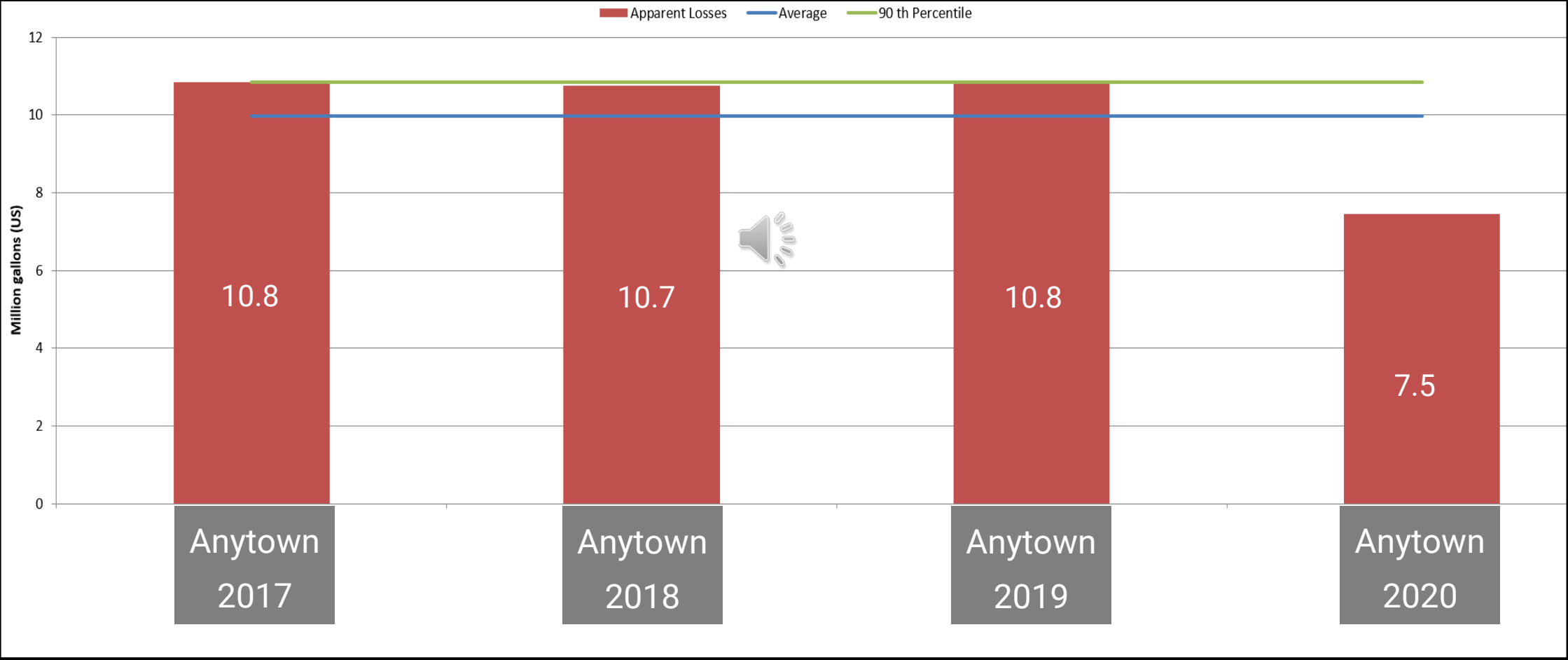
Use the AWWA Compiler tool to see year-by-year trends in your system

Compare your Apparent and Real loss volumes and rates to the target values that you established – are you reaching your targets?



A. Tracking Your Progress in Controlling Non-revenue Water

Place water audit data in the **AWWA Compiler Tool** for trending



Annual Apparent Loss Volumes in million gallons for Anytown Water Utility, 2017-2020



A. Track Your Progress in Controlling Non-revenue Water – **KNOWLEDGE CHECK**

True or False: The AWWA Compiler Tool can chart water audit data from a single water utility across the years?



True



False



B. Making Adjustments as Needed

Be ready to change course if results are not what you expect.

Some examples might include:

- **Acoustic leak detection isn't finding many leaks: consider installing a District Metered Area on a pilot basis**
- **Many customer meters were replaced, but billed consumption has not increased: investigate the customer billing system for errors**
- **Continue to improve water audit data validity**



B. Making Program Adjustments as Needed: **KNOWLEDGE CHECK**

 **A utility water audit revealed high leakage, so the utility hired a leak detection contractor who found relatively few leaks, despite a system of older piping and high pressure. The utility might consider changing its focus to:**

- a. Conducting leak detection  using inhouse staff
- b. Replace all customer water meters
- c. Replacing all piping in the distribution system
-  d. Piloting a District Metered Area with pressure management



C. Tips for Continued Progress

Improve your water audit knowledge by:

- 💧 **compiling the water audit each year**
- 💧 **obtaining additional water audit training**
- 💧 **have your water audit validated by a knowledgeable third party**
- 💧 **access additional resources from AWWA's Water Loss Control pages (see below link)**



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



C. Tips for Continued Progress



Pilot new technology

- 💧 Metering and advance meter reading and data analytics
- 💧 Computerized customer billing systems
- 💧 Leakage and pressure management
- 💧 Advanced analytics: machine learning and artificial intelligence apply to water distribution system management



C. Tips for Continued Progress

Stay up to date with available resources, training, and funding opportunities

- ◆ American Water Works Association (AWWA)
- ◆ United States Department of Agriculture (USDA)
- ◆ Rural Community Assistance Partnership (RCAP)
- ◆ Infrastructure Investment & Jobs Act (2021) – includes \$50 billion to the Environmental Protection Agency (EPA) to strengthen water and wastewater infrastructure.
 - Drinking Water State Revolving Fund Primacy Agencies in each US state



Module 2 Summary

Be certain to track the progress of your Non-revenue Water Management Program

Be prepared to adjust your goals and methods if your initial loss control efforts aren't matching expectations



Tap into training, technology and funding from trade associations and government agencies to improve your skills, obtain funding and resources, and use innovative technology to control Non-revenue Water



Course 5 & eLearning Series Summary

In Course 5 we learned about ways to keep your Non-revenue Water Management Program going once its launched

We described the need to continually address NRW, compile the annual water audit, plan and budget for loss reduction, track your progress, and adjust as needed

Through this eLearning series, we learned about the components of Non-revenue Water, how it occurs and how to compile the water audit to track volumes and costs

We also learned about effective methods to control apparent and real (leakage) losses

We hope that you gained valuable information to control Non-revenue Water effectively!



Before you leave the course

HOMework

What actions will you take to audit your water system and to control Non-revenue Water?



Course 5

Final Assessment Questions

(See accompanying list)





AWWA eLearning
Thank you for completing Course 5
**Keeping an Effective Non-revenue
Water Management Program Going**
And for completing the series
**Controlling Non-revenue Water in
Drinking Water Utilities**

