Asheville, NC – 10 years of Water Loss Control

… and Counting

CAVANAUGH
Stewardship Through Innovation

M. Steve Cavanaugh, Jr., PE
steve.cavanaugh@cavanaughsolutions.com

May 10, 2018

Pennsylvania AWWA
American Water Works Association

Agenda

National Water Loss Movement – Tools review

Audit to Action – Asheville Case Study

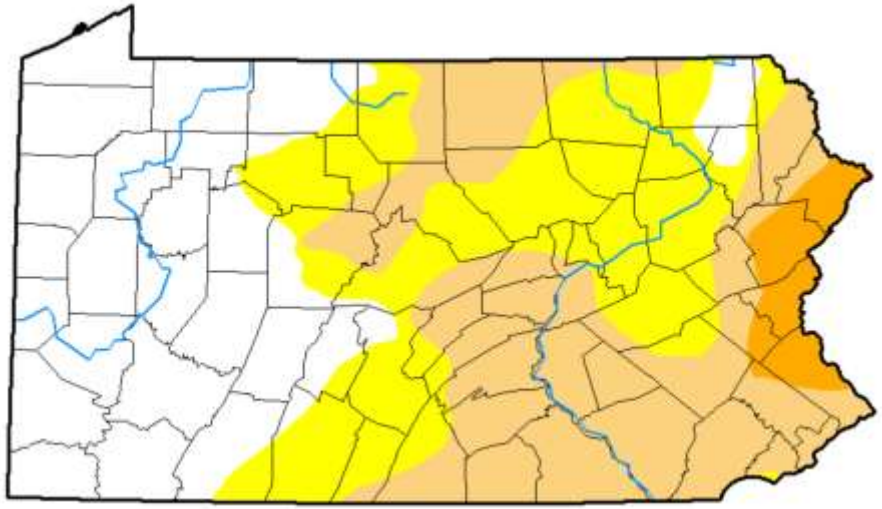
What’s next for your utility?

What's next for Pennsylvania?

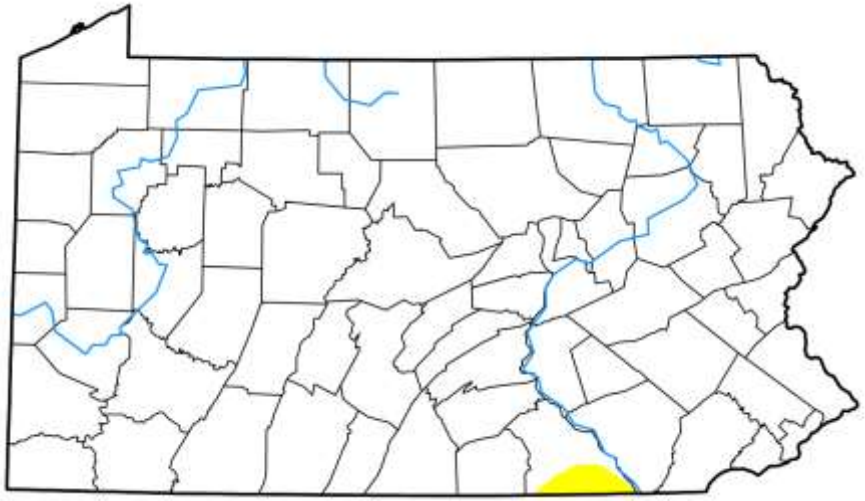
Q&A

Problem has gone away…?

November 15, 2016



April 12, 2018



Source: US Drought Monitor

Problem has gone away…?

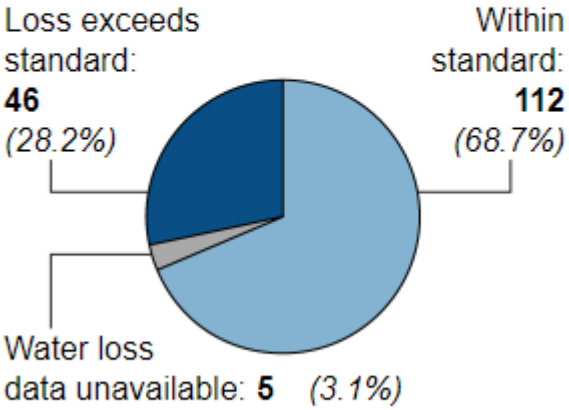
SAWS reveals 9 billion gallons of water wasted last year

by APRIL MOLINA | Wednesday, November 1st 2017

Communities compliant with Illinois water loss standard

For 163 Illinois municipalities that received Lake Michigan water in 2016

Illinois standard: 12% water lost



SOURCE: Tribune reporting, Illinois Department of Natural Resources

CHICAGO TRIBUNE

American Water Works Association

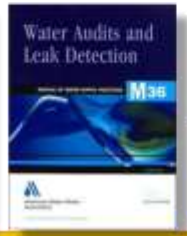
Water Research Foundation

Ongoing Research & Development:

Performance Indicator Task Force
WRF 4695-Effective WLC Planning

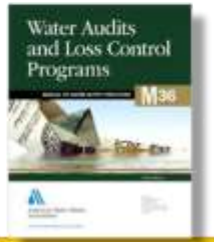
M36 1st Ed.

M36 2nd Ed.



AWWA adopts international standard, abandons Unaccounted For Water

M36 3rd Ed.



WRF study shows audit validity is a widespread challenge

M36 4th Ed.

Validation method developed

1991 | 1999 | 2003 | 2006 | 2009 | 2010 | 2014 | 2015 | 2016 | 2017

AWWA Audit Software v1

AWWA Audit Software v4

(2,000 downloads)

AWWA Audit Software v5

NORTH AMERICAN WATER LOSS 2015

Georgia

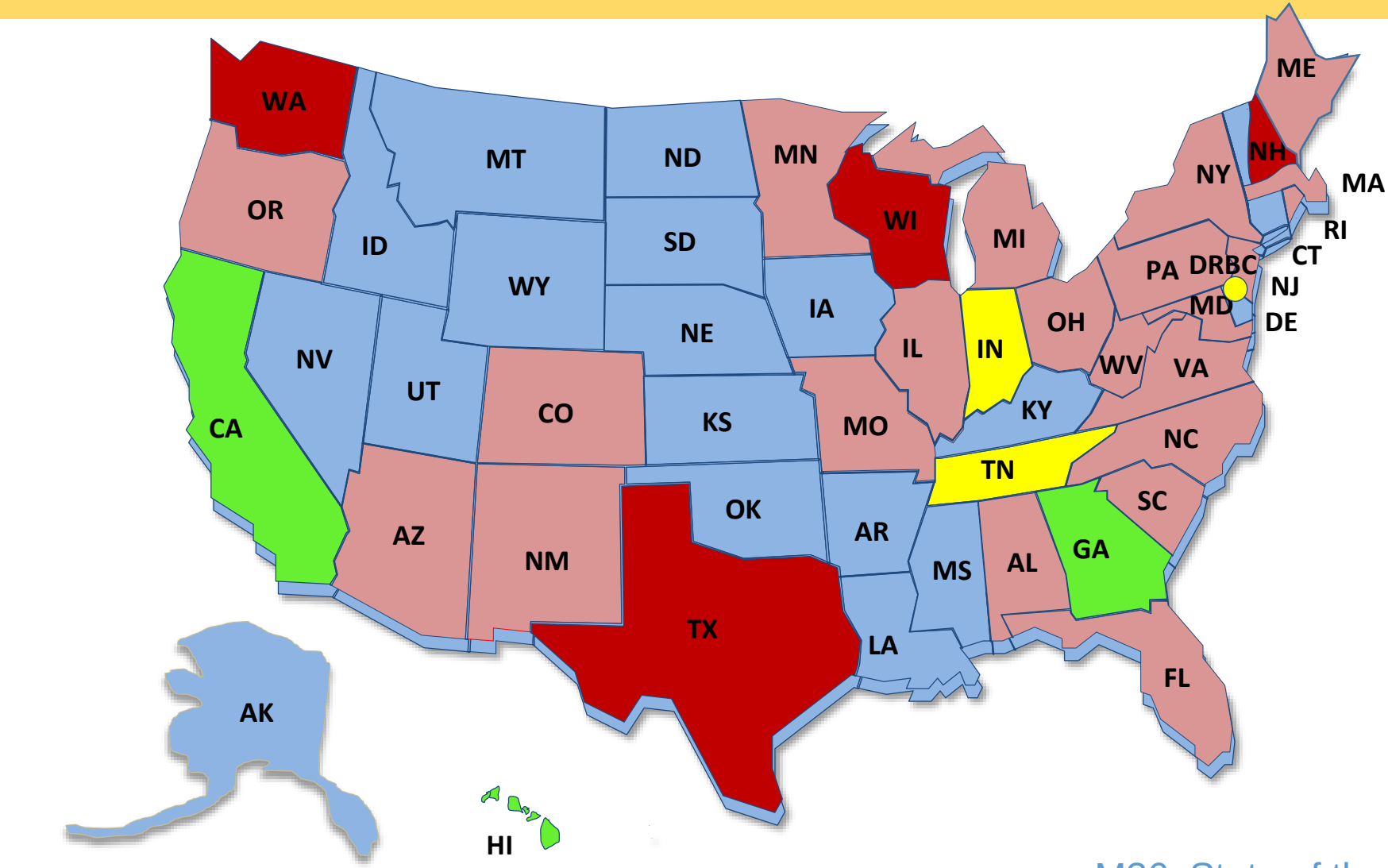
NORTH AMERICAN WATER LOSS 2017

California

~8,000 downloads to date of AWWA Audit Software v5

AWWA Compiler developed for large audit sets

WRF Real Loss Component Analysis Model



M36: State of the Art

Statewide Water Loss Management Program – Model Implementation

Phase 1

Establish Annual M36 Water Auditing

Auditing
- Establish annual M36 Water Auditing for all utilities

Outreach
- Educate Regulatory Community on M36 Method and appropriate use of performance indicators
- Establish Statewide Water Loss Control Committee

Training & Tech Asst
- Develop State Manual and Training Framework
- Provide extended, progressive training to utilities (funded)

Phase 2

Achieve Minimum Standard of Audit Reliability

Data Manage-ment
- Develop and implement data management system
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Validation
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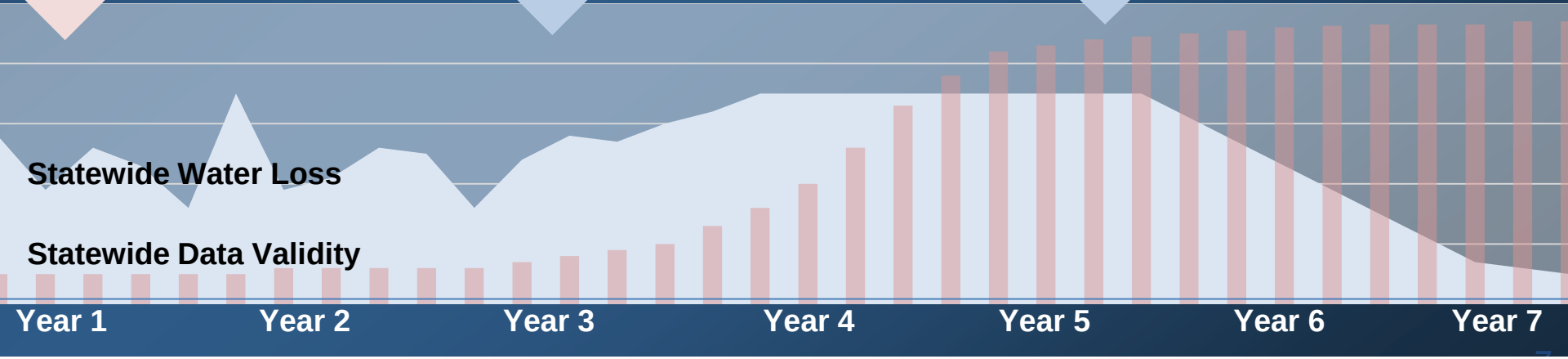
Phase 3

Manage Water Loss Performance for Long-Term Reduction

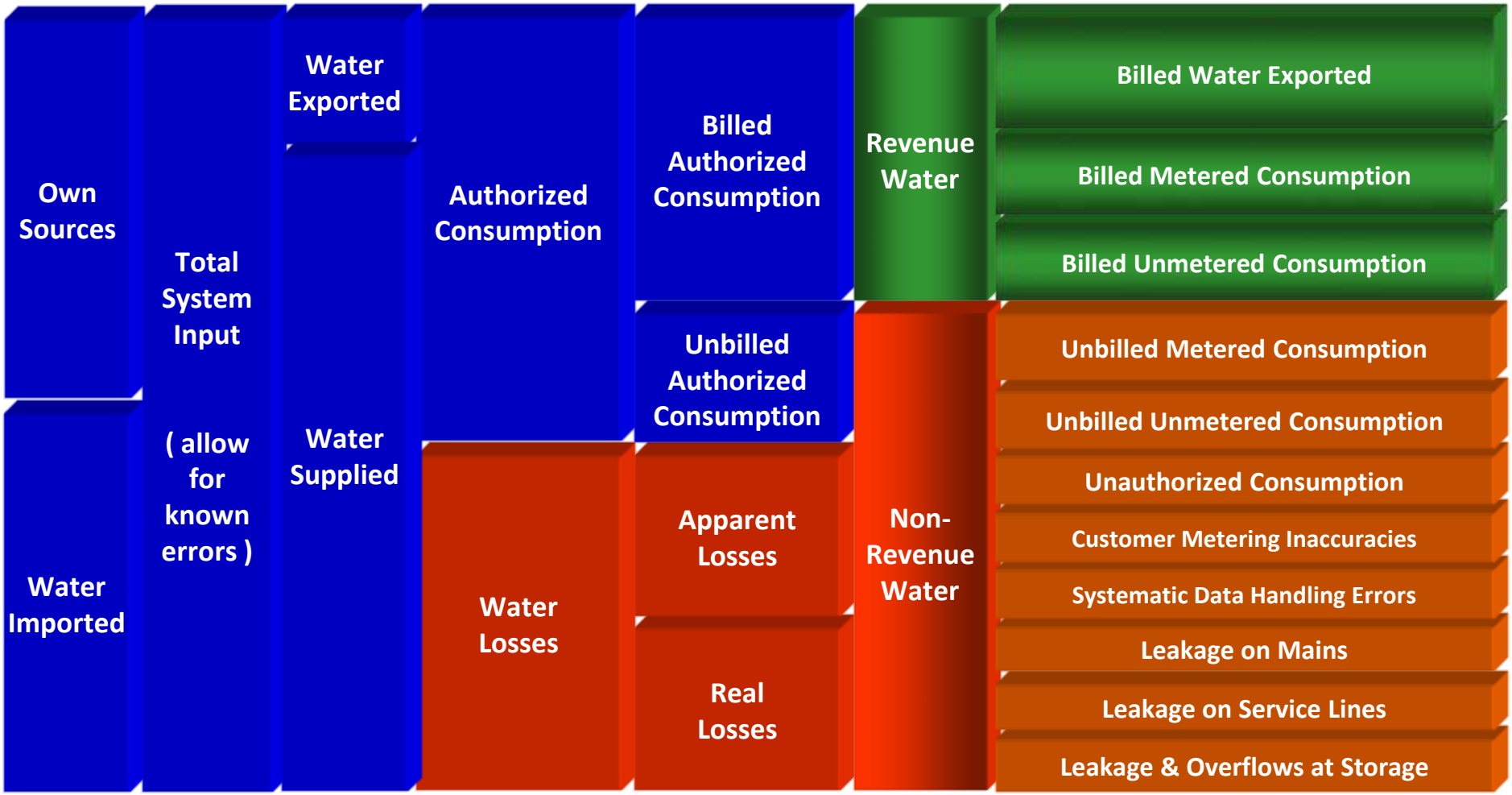
Benchmarking
- Suite of Performance and Process Measures
- System specific improvement over time in a cost-effective manner
- No universal targets
- Excessive thresholds established

Improvement
- Annual audit submission threshold exceedances
- System specific progress review at designated regulatory touchpoints



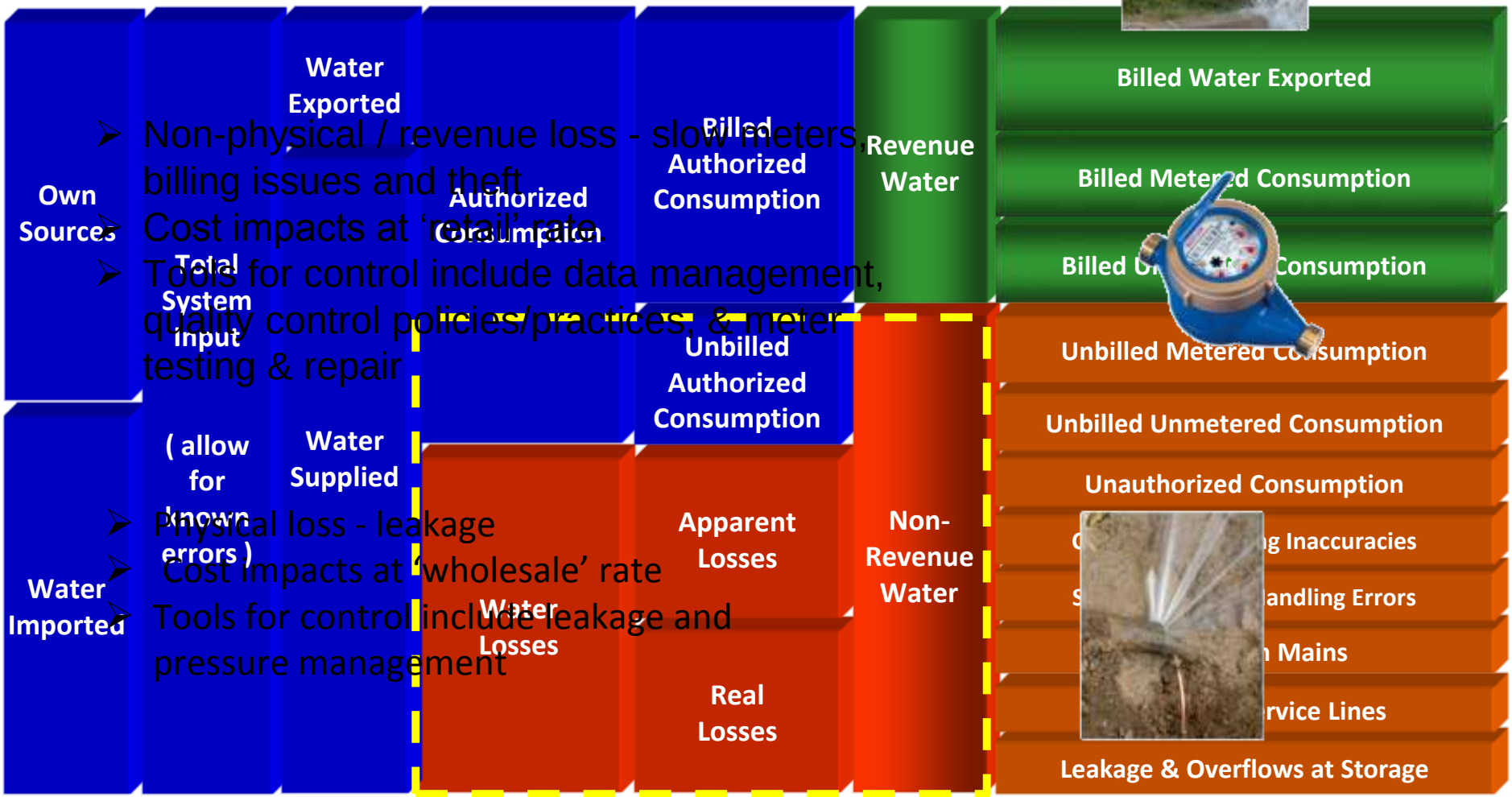
Resource Management Grade C | Resource Management Grade B | Resource Management Grade A

IWA/AWWA Standard Water Balance



Management of NRW

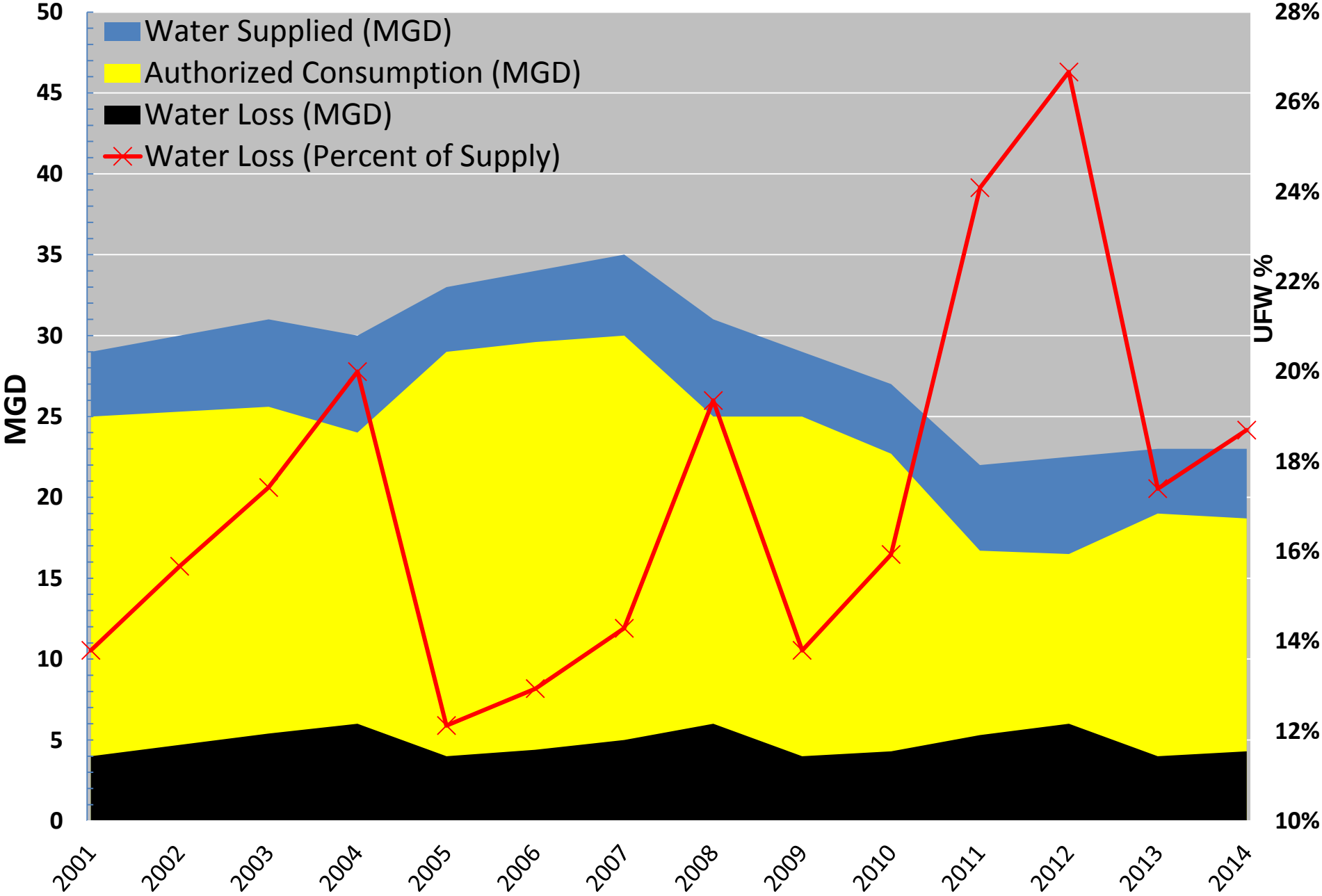
- Fire Dept Usage
- Operational Flushing
- Tools for control include efficient flushing practices and awareness campaigns



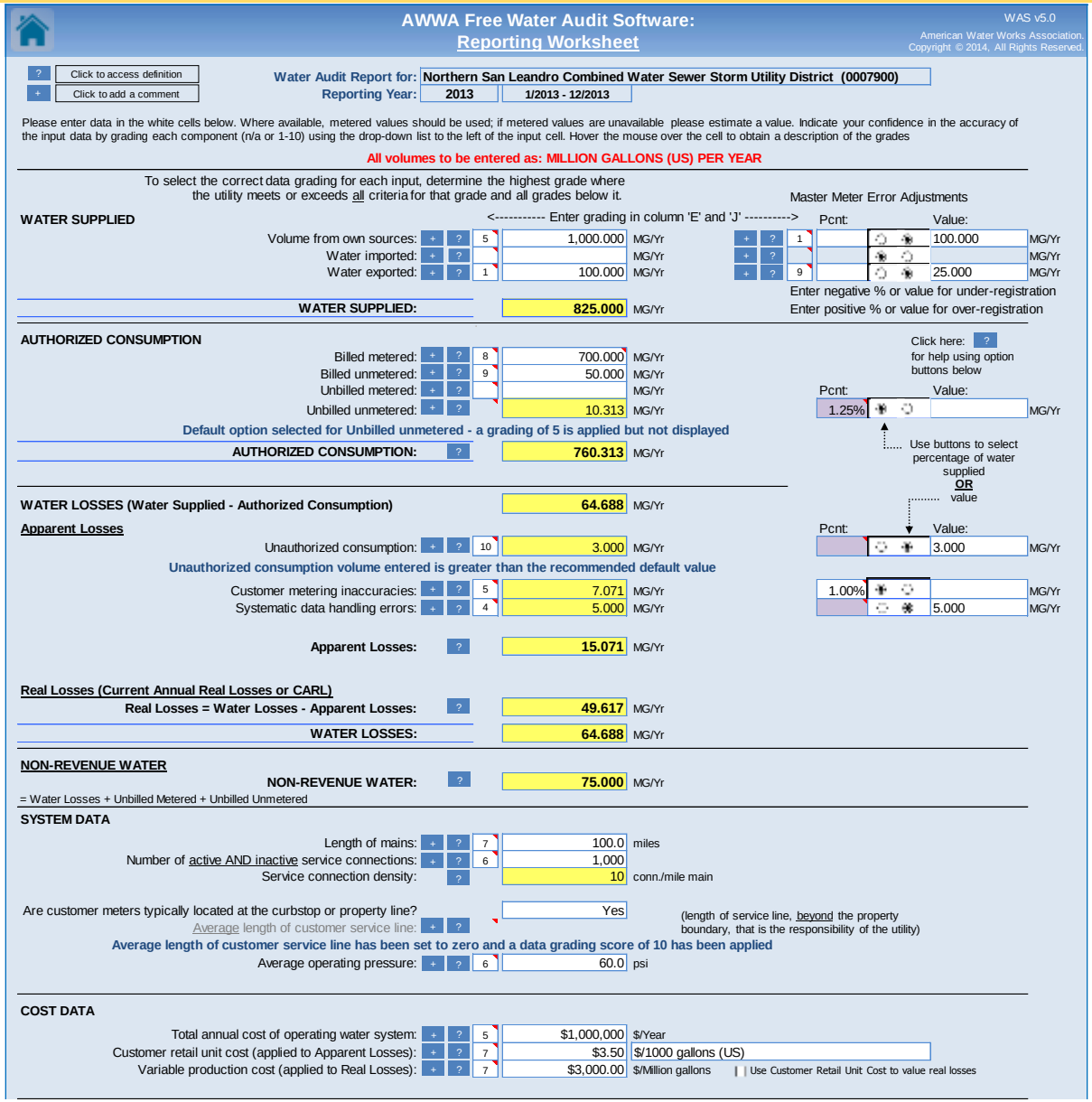
- Non-physical / revenue loss - slow meters, billing issues and theft
- Cost impacts at 'retail' rate
- Tools for control include data management, quality control policies/practices, & meter testing & repair

- Physical loss - leakage
- Cost impacts at 'wholesale' rate
- Tools for control include leakage and pressure management

Water Loss as a Percentage of Supply is not an Indicator of Performance



AWWA Free Water Audit Software



Industry Standard (M36)

Free

Defaults provided

~10 Volume Inputs

~7 System Data Inputs

awwa.org/waterlosscontrol

AWWA Free Water Audit Software

Performance Indicators/Metrics

AWWA Free Water Audit Software:
System Attributes and Performance Indicators

WAS v5.0

Water Audit Report for: City of Orem (UT4900332)
Reporting Year: 2016 | 7/2015 - 6/2016

*** YOUR WATER AUDIT DATA VALIDITY SCORE IS: 55 out of 100 ***

+ Real Losses:	555.653	MG/Yr
= **Water Losses:**	**772.682**	MG/Yr
? Unavoidable Annual Real Losses (UARL):	170.51	MG/Yr
Annual cost of Apparent Losses:	$233,740	
Annual cost of Real Losses:	$213,979	Valued at **Variable Production Cost**

Return to Reporting Worksheet to change this assumpiton

Performance Indicators:

Financial:	Non-revenue water as percent by volume of Water Supplied:	14.8%	
	Non-revenue water as percent by cost of operating system:	5.0%	Real Losses valued at Variable Production Cost
Operational Efficiency:	Apparent Losses per service connection per day:	26.11	gallons/connection/day
	Real Losses per service connection per day:	66.85	gallons/connection/day
	Real Losses per length of main per day*:	N/A	
	Real Losses per service connection per day per psi pressure:	0.77	gallons/connection/day/psi
	From Above, Real Losses = Current Annual Real Losses (CARL):	555.65	million gallons/year
	? Infrastructure Leakage Index (ILI) [CARL/UARL]:	3.26	

* This performance indicator applies for systems with a low service connection density of less than 32 service connections/mile of pipeline

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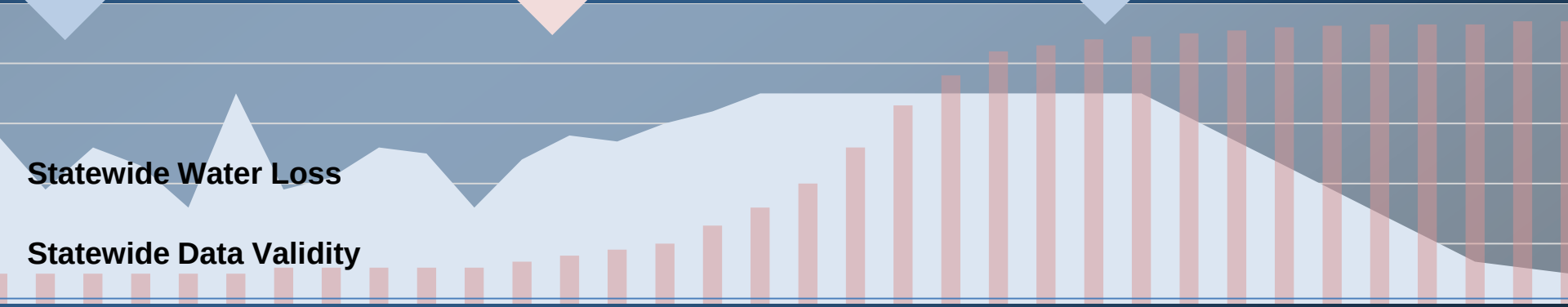


Resource Management Grade C | Resource Management Grade B | Resource Management Grade A

AWWA Free Water Audit Software© (V5.0)
Data Grading for each Water Audit input (excerpt)

AWWA Free Water Audit Software:
Reporting Worksheet

WAS v5
American Water Works Assn
Copyright © 2014, All Rights Re

? Click to access definition
+ Click to add a comment

Water Audit Report for: << Please enter system details and contact information on the Instructions tab >>
Reporting Year:

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

PLEASE CHOOSE REPORTING UNITS FROM THE INSTRUCTIONS SHEET BEFORE ENTERING DATA

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 Error Adjustments

WATER SUPPLIED

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

Volume from own sources:
Water imported:
Water exported:

WATER SUPPLIED:

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. Le 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.

AUTHORIZED CONSUMPTION

Billed metered:
Billed unmetered:
Unbilled metered:
Unbilled unmetered:

Enter a positive value, otherwise a default percentage of 1.25% (of billed metere

AUTHORIZED CONSUMPTION:

WATER LOSSES (Water Supplied - Authorized Consumption) 0.000

value

Apparent Losses

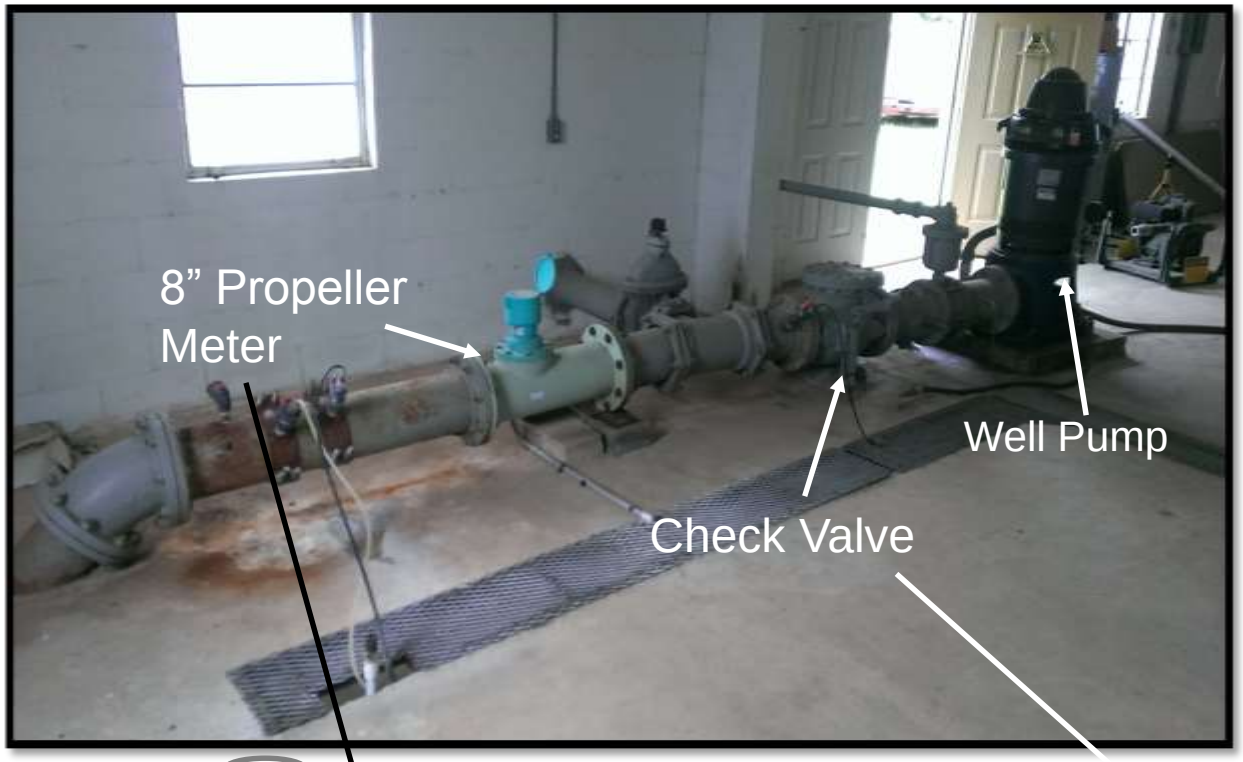
Pcnt: Value:

Unauthorized consumption: 0.000 — 0.25%

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

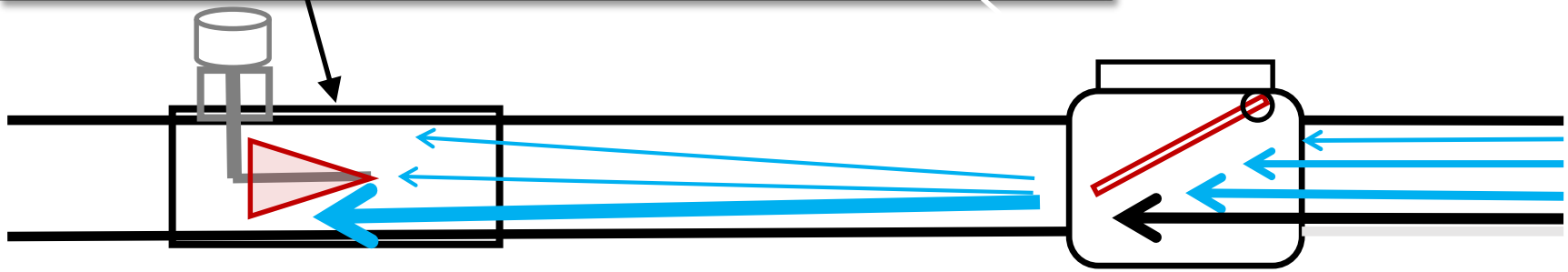
Customer metering inaccuracies: 0.000 — 1.00%
Systematic data handling errors: 0.000 — 0.25%

Accuracy in the Water Balance



Accuracy results from MFR test bench: 99.5%

Accuracy results from in-situ test: 142.2%



Courtesy MESCO

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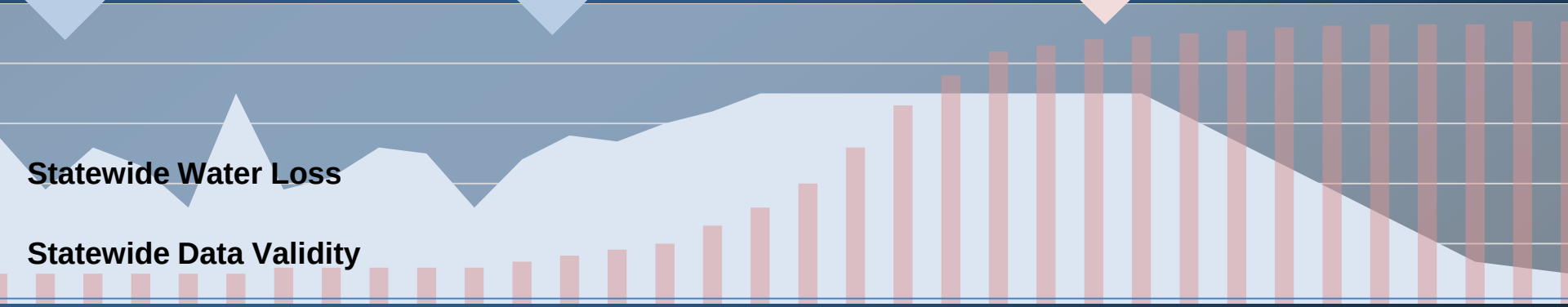


Resource Management Grade C | Resource Management Grade B | Resource Management Grade A

M36: State of the Art

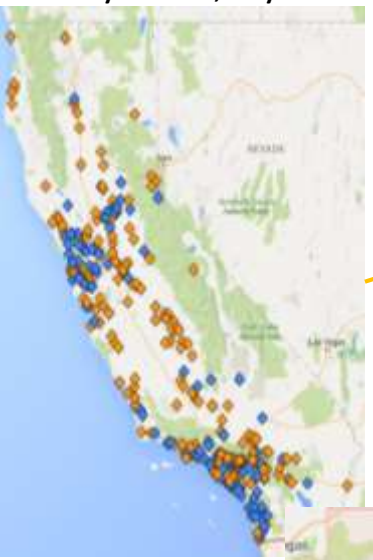
Washington Pilot
10 systems, 9 months

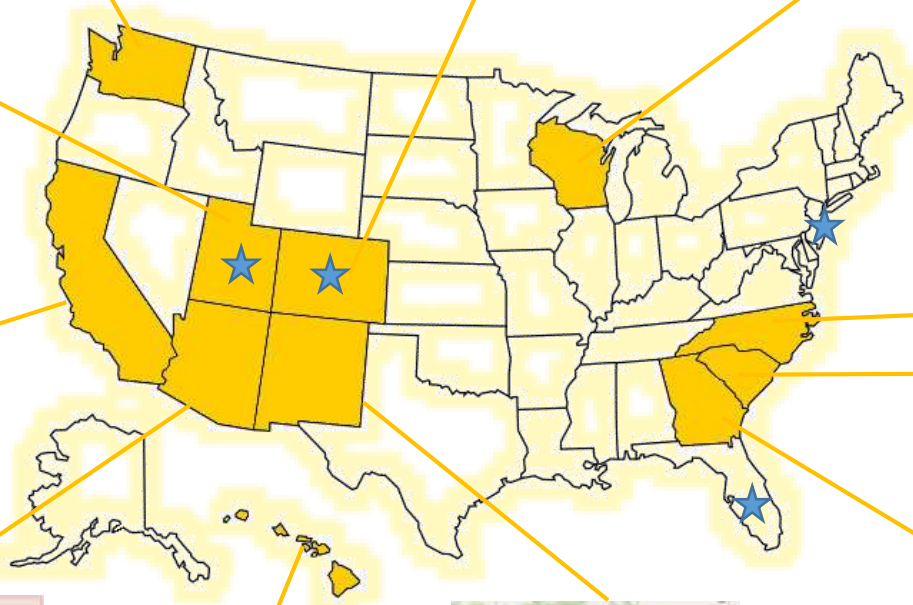
Colorado Pilot
50 systems, 3 months

Wisconsin Pilot
6 systems, 6 months

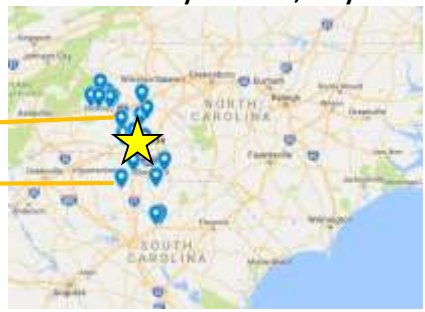
Utah Pilot
20 systems, 6 months

California Full Scale
460 systems, 2 years





North & South Carolina Pilot
18 systems, 1 year



Arizona Pilot
6 systems, 6 months

Hawaii Full Scale
100 systems, 4 years

New Mexico Full Scale
134 systems, 1 year

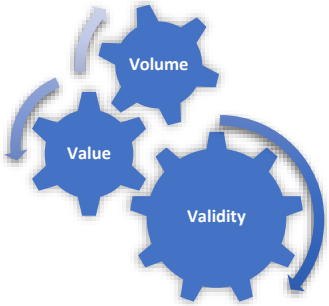
Georgia Full Scale
230 systems, 5 years (and counting)

The Big Picture: Economic Intervention

Annual Water Balance

- Annual M36 water audit
- Apparent & Real Loss volumes
- Level 1 validation

baseline



Loss Profiling

- Validation
  - Level 2 Analytics
  - Level 3 Field Study
- Analyze sources of Apparent Loss
- Analyze 3 types of Real Loss

technical analysis

Cost-Benefit & Targets

- Costs of losses
  - by subcomponent
  - in aggregate
- Costs of intervention strategies
- Program design
- System-specific

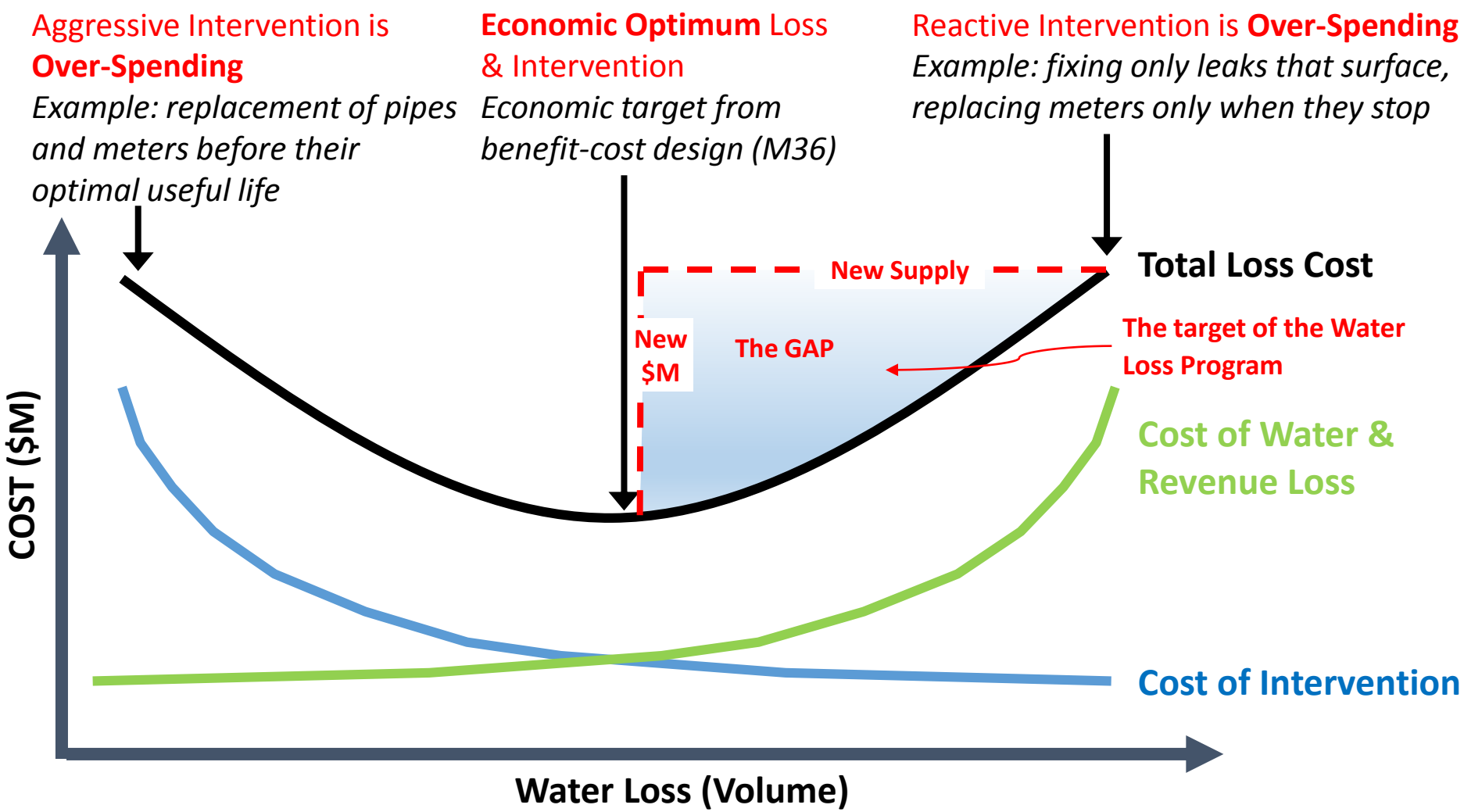
economic analysis

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

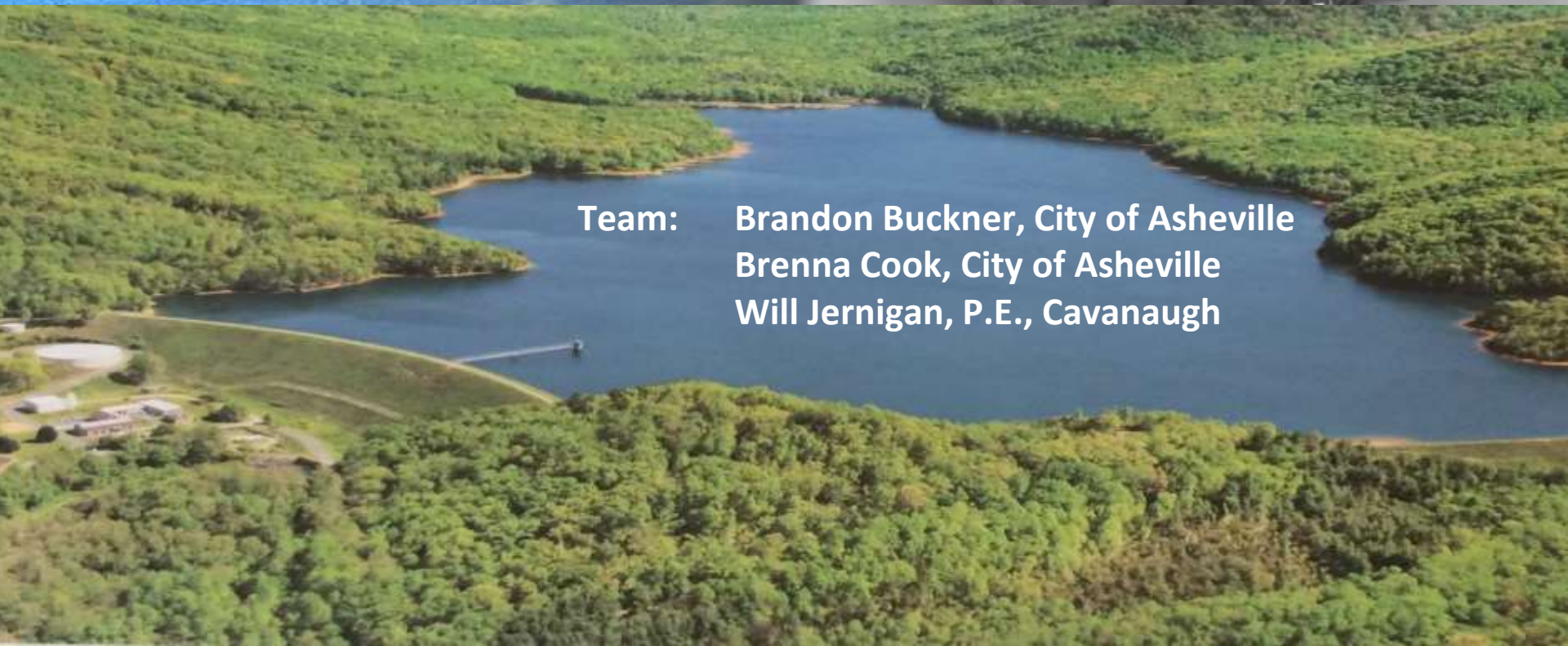
cost-effectiveness

AWWA M36 – Economic Optimum



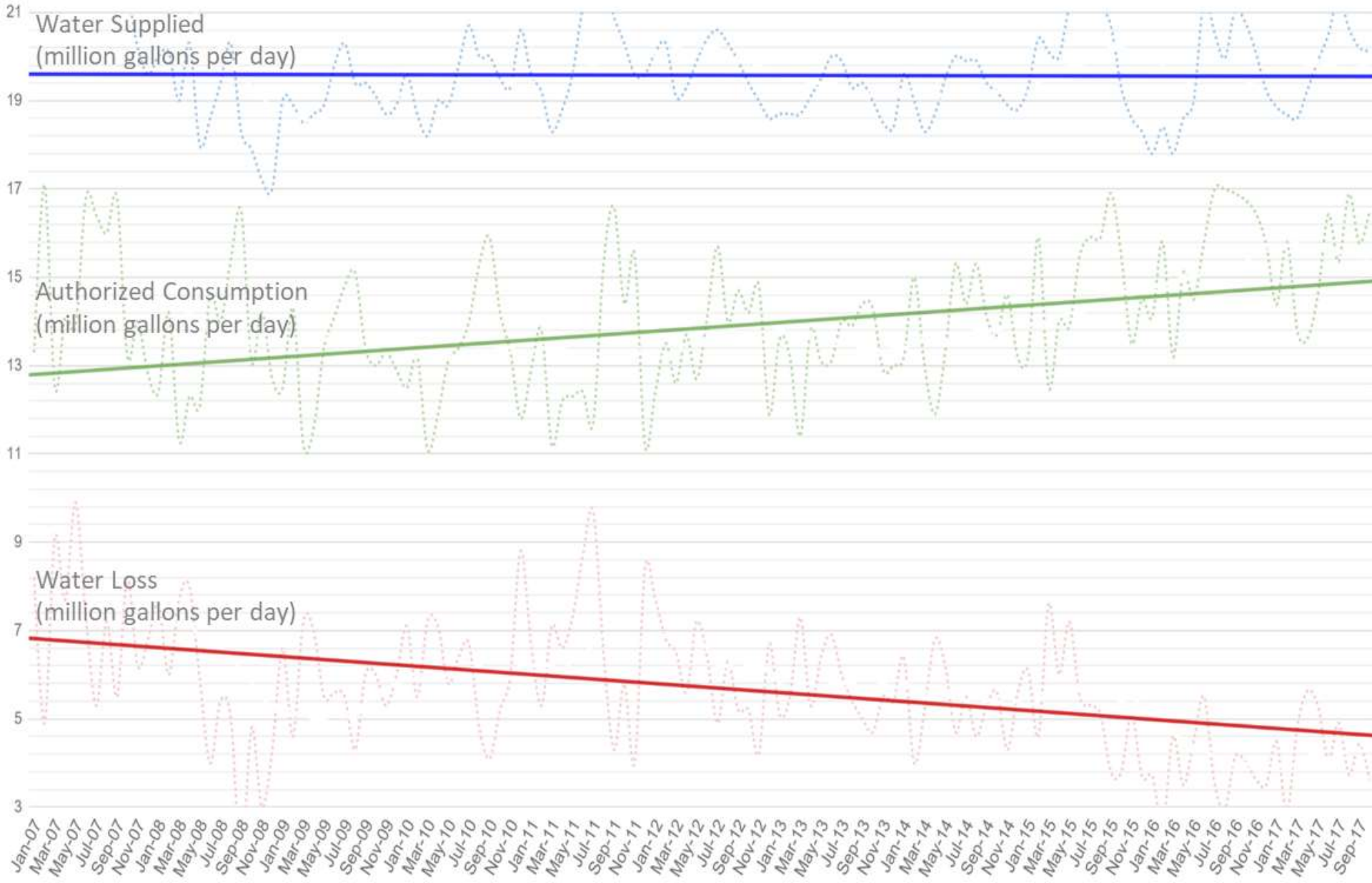
City of Asheville Comprehensive Non-Revenue Water Program

CAVANAUGH
Stewardship Through Innovation

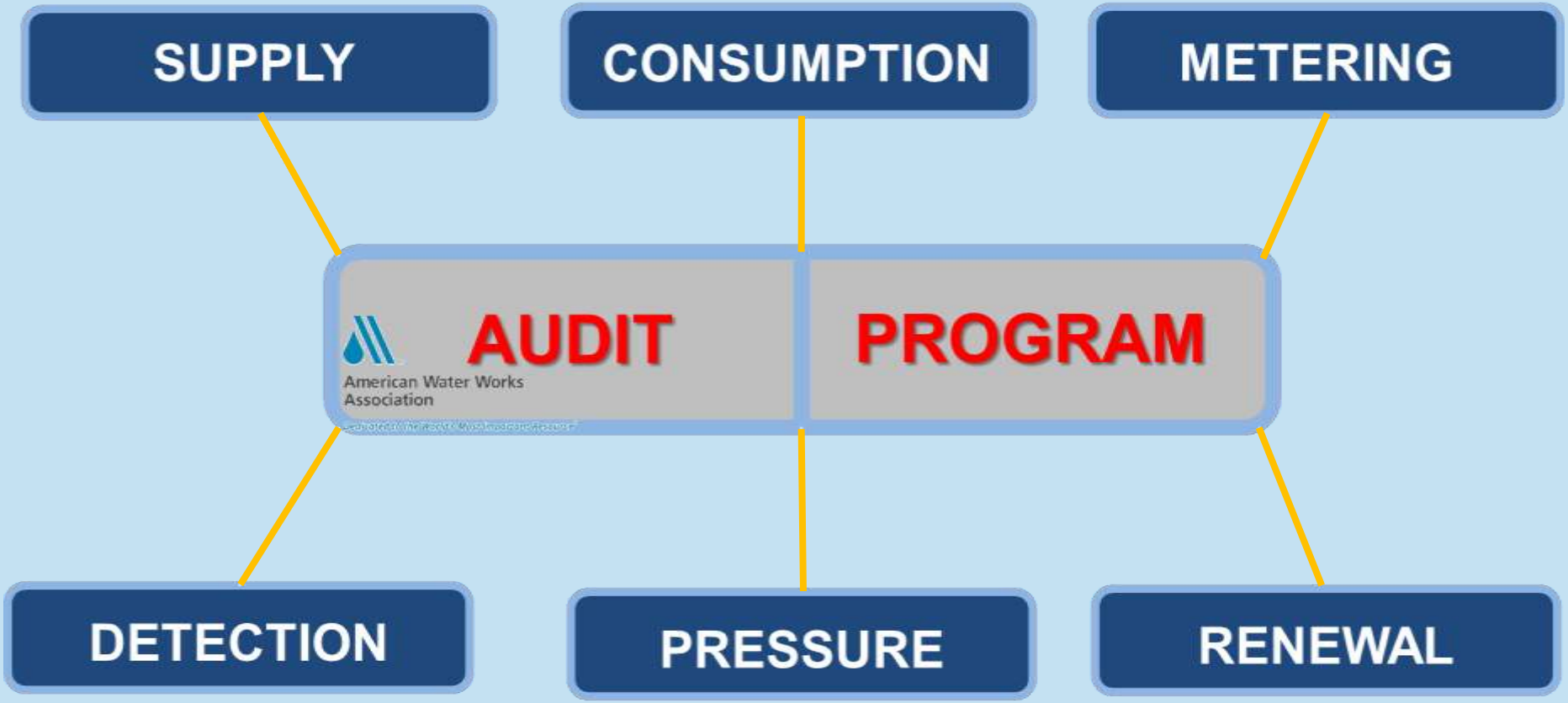


Team: Brandon Buckner, City of Asheville
Brenna Cook, City of Asheville
Will Jernigan, P.E., Cavanaugh

Program Origins



Audit to Action

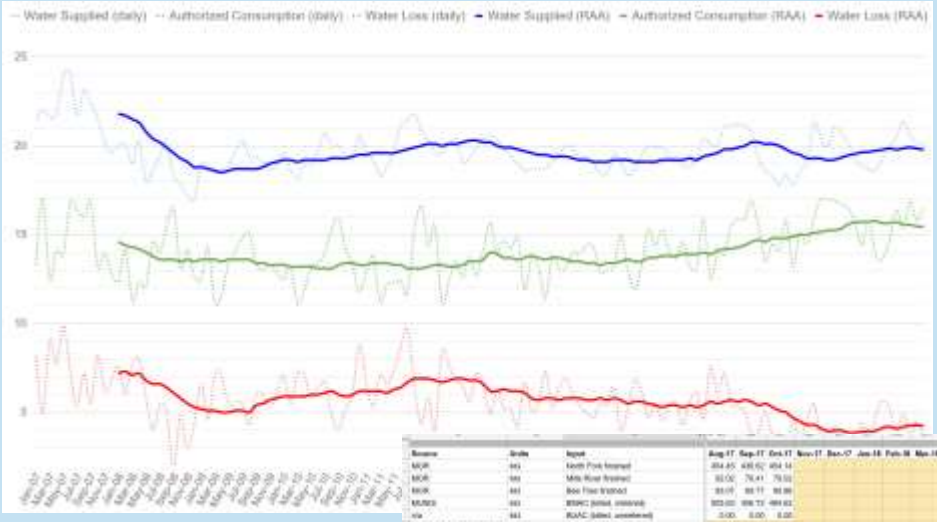


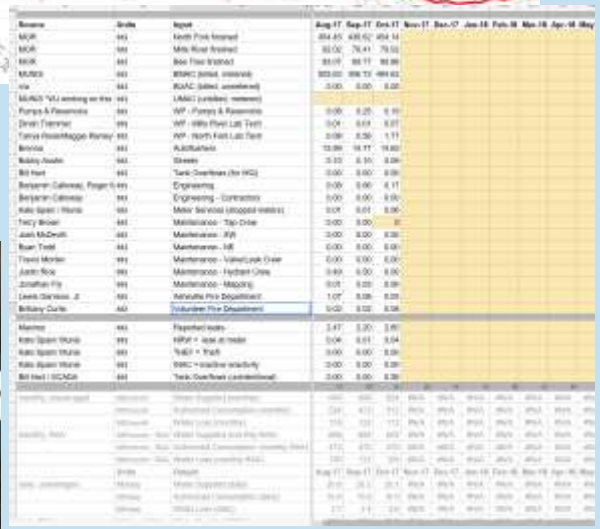
A Team Based Approach

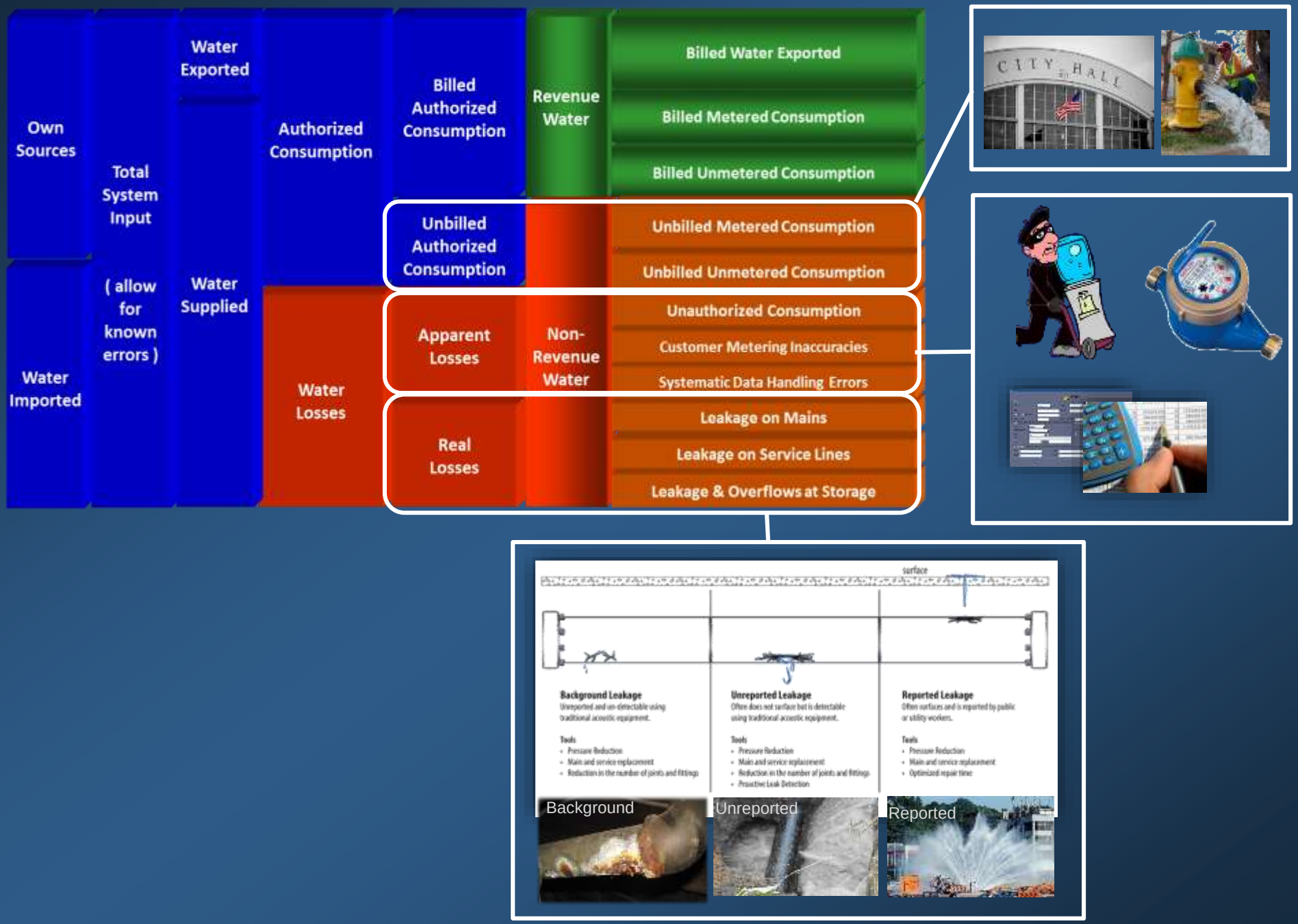
- Audit Input Team
- Valve & Leak Team
- Unbilled Customer Team
- Customer Service Team
- Metering Team
- Pressure Management Team

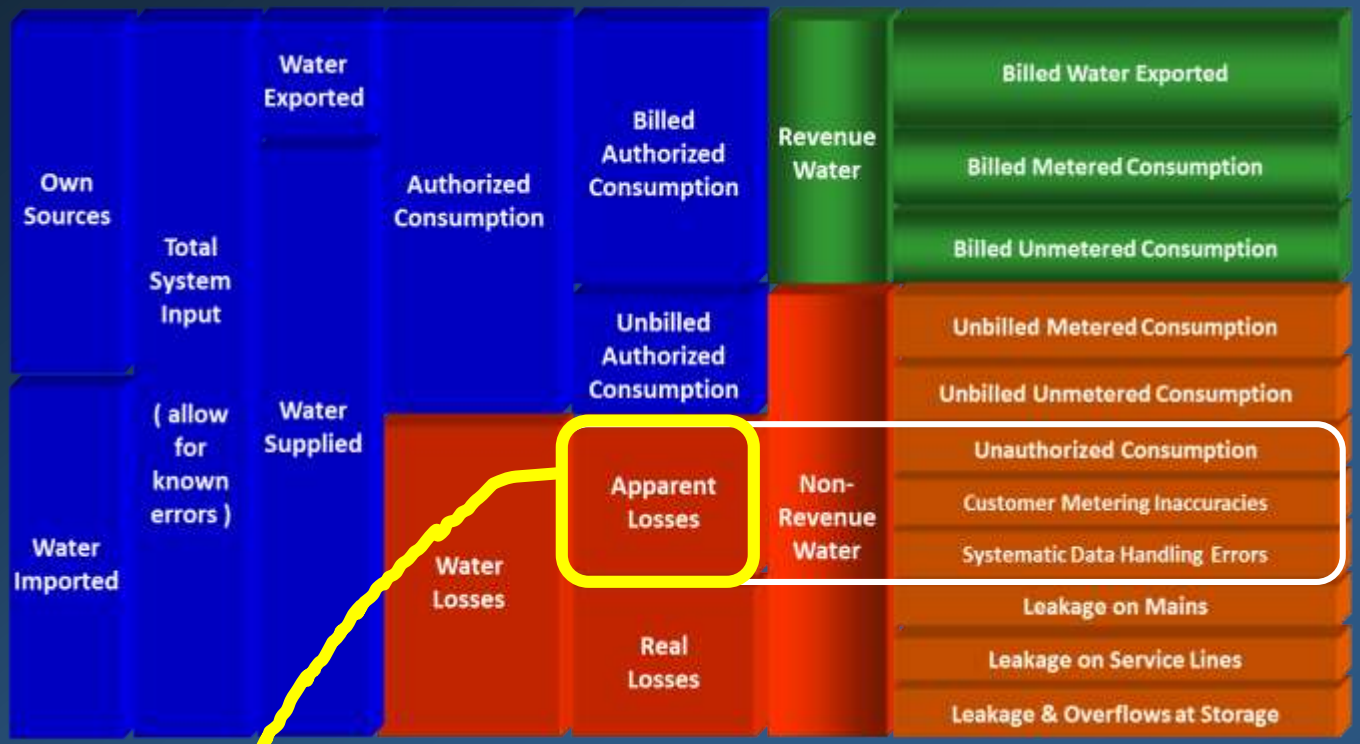
Data Tracking & Audit Input

- Assist in Gathering Data
- Master Meter Testing
- Water Theft Tracking
- Reporting from Internal & External sources
- KPI Tracker
- Policy Relation & Review
- CIP Recommendations





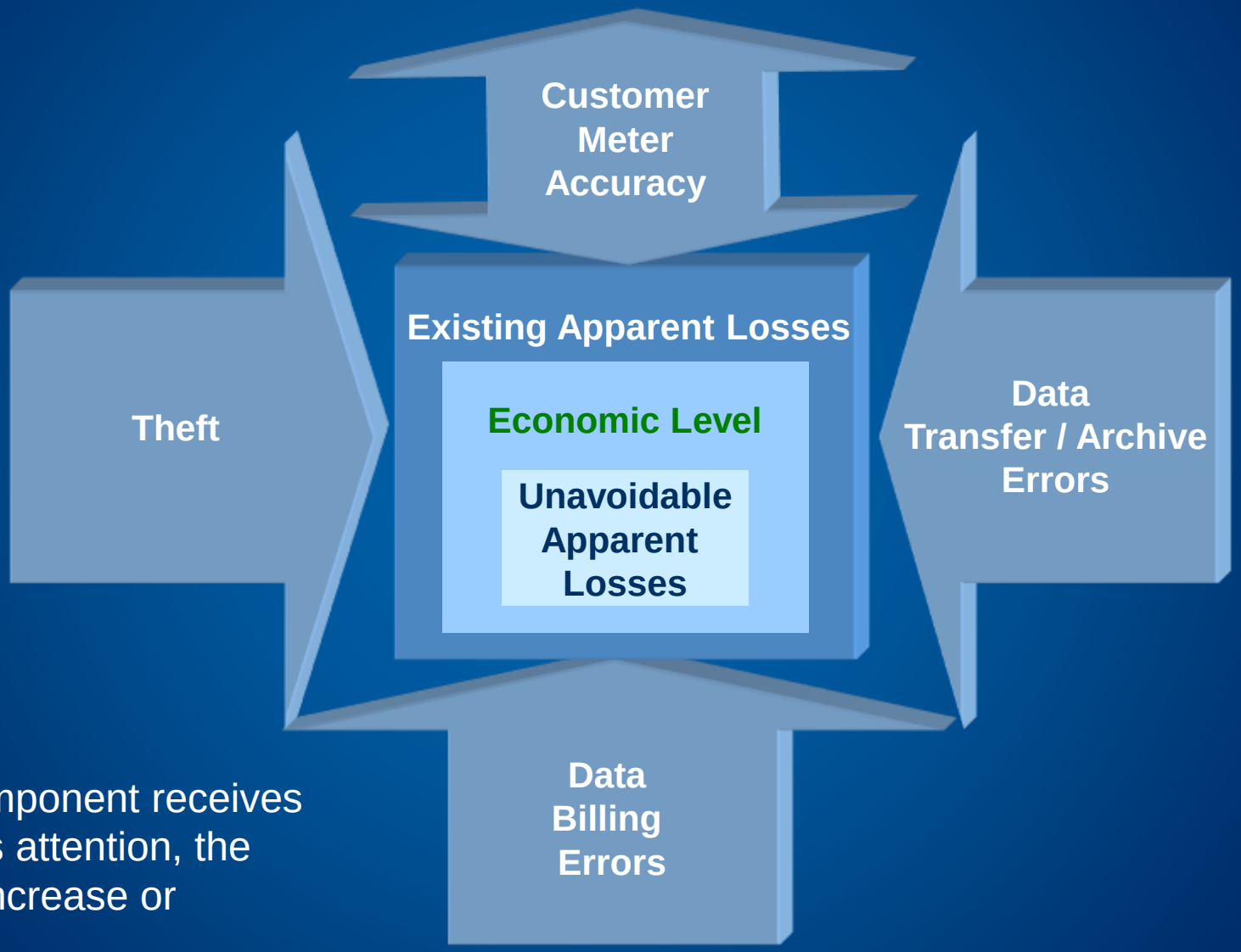

Own Sources
Water Imported
Total System Input
(allow for known errors)
Water Exported
Water Supplied
Authorized Consumption
Water Losses
Billed Authorized Consumption
Unbilled Authorized Consumption
Apparent Losses
Real Losses
Revenue Water
Non-Revenue Water
Billed Water Exported
Billed Metered Consumption
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
CITY HALL
surface
Background Leakage
Unreported Leakage
Reported Leakage
Tools
Background
Unreported
Reported



Apparent Losses

=

Four Pillars of Managing Apparent Loss



As each component receives more or less attention, the losses will increase or decrease

Source: AWWA Water Loss Control Committee


Own Sources
Water Imported
Total System Input
(allow for known errors)
Water Exported
Water Supplied
Authorized Consumption
Water Losses
Billed Authorized Consumption
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Billed Water Exported
Billed Metered Consumption
Billed Unmetered Consumption
Unbilled Metered Consumption
Unbilled Unmetered Consumption
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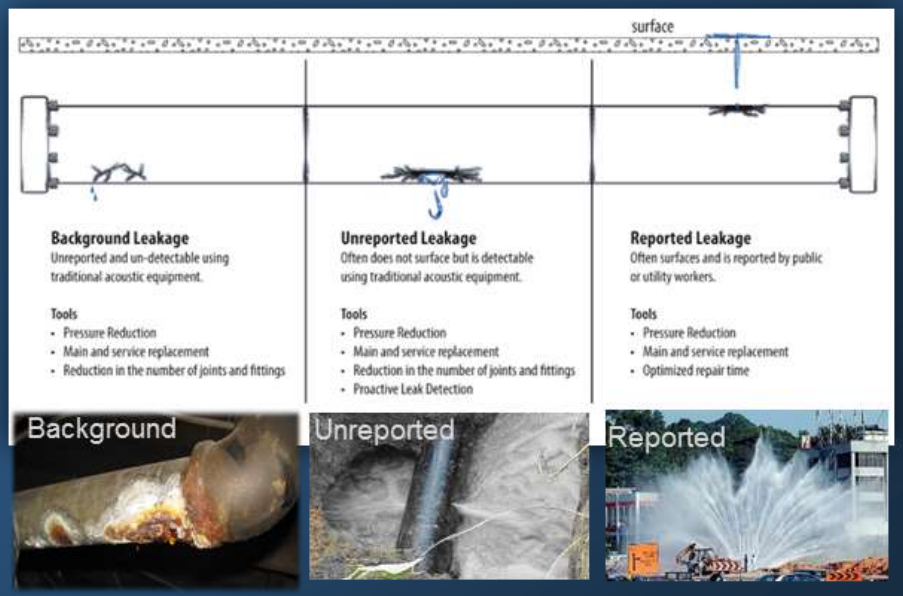
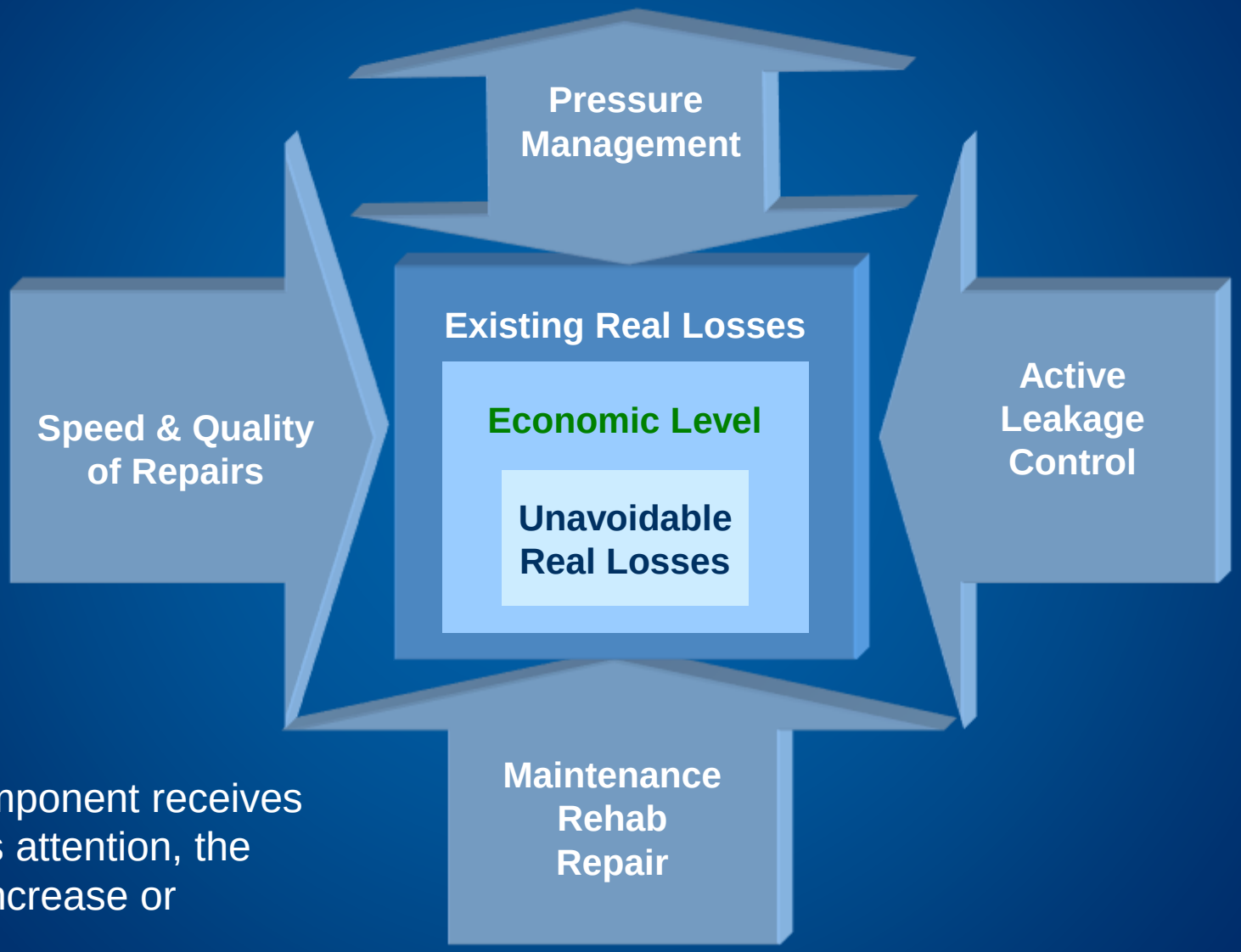
Systematic Data Handling Errors
Leakage on Mains
Leakage on Service Lines
Leakage & Overflows at Storage

Real Losses

=


surface
Background Leakage
Unreported and un-detectable using traditional acoustic equipment.
Tools
• Pressure Reduction
• Main and service replacement
• Reduction in the number of joints and fittings
Unreported Leakage
Often does not surface but is detectable using traditional acoustic equipment.
Tools
• Pressure Reduction
• Main and service replacement
• Reduction in the number of joints and fittings
• Proactive Leak Detection
Reported Leakage
Often surfaces and is reported by public or utility workers.
Tools
• Pressure Reduction
• Main and service replacement
• Optimized repair time
Background
Unreported
Reported

Four Pillars of Managing Leakage



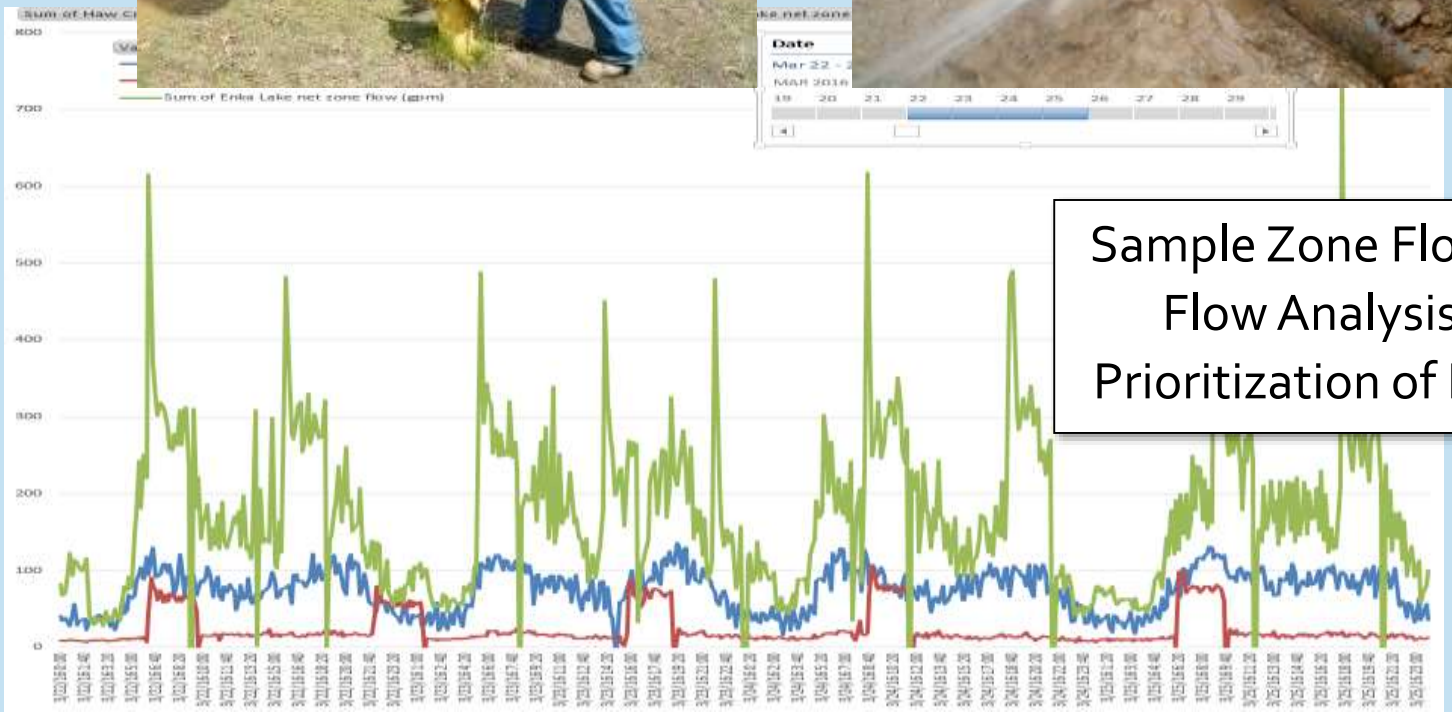
As each component receives more or less attention, the losses will increase or decrease

Source: AWWA Water Loss Control Committee

Fire Department Audits

- Check for use of NRW
- Billing/Metering status
- Create Consistency
- Recommendations for Improvement
- Follow up

Proactive Leak Surveys



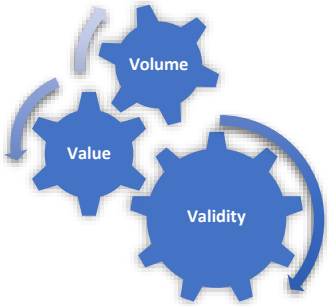
Sample Zone Flows for 'Night Flow Analysis' to Guide Prioritization of Leak Surveys

The Big Picture: Economic Intervention

Annual Water Balance

- Annual M36 water audit
- Apparent & Real Loss volumes
- Level 1 validation

baseline



Loss Profiling

- Validation
  - Level 2 Analytics
  - Level 3 Field Study
- Analyze sources of Apparent Loss
- Analyze 3 types of Real Loss

technical analysis

Cost-Benefit & Targets

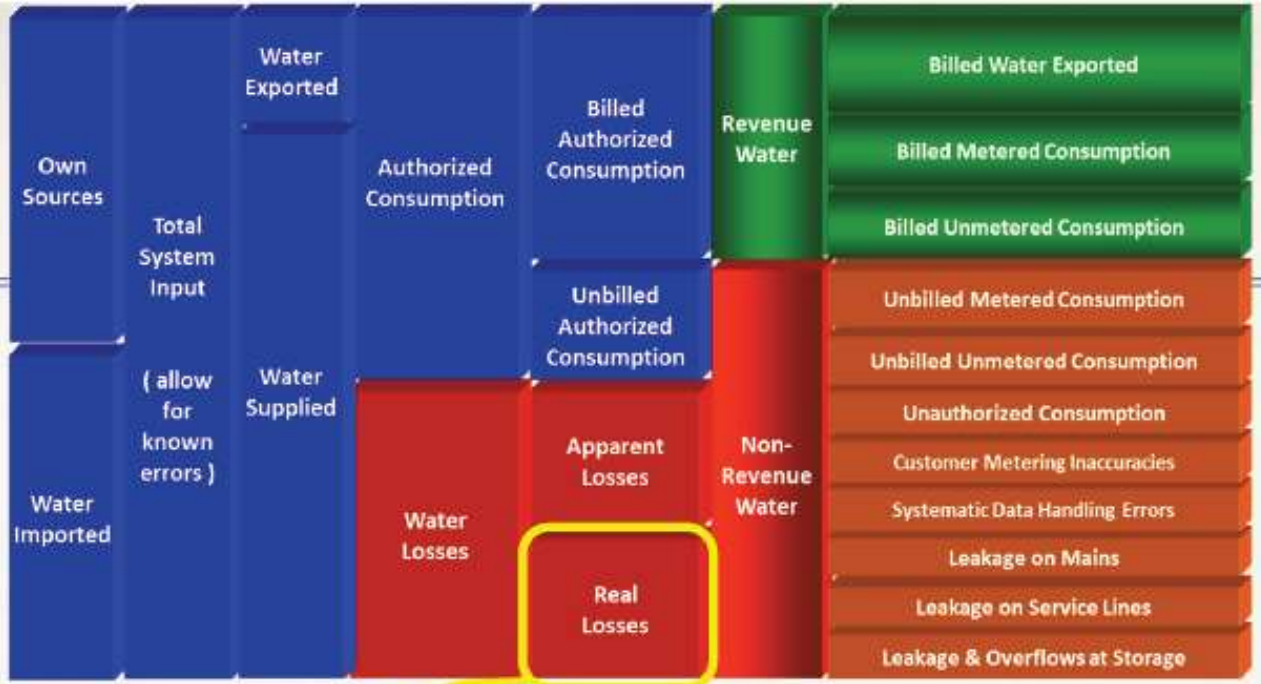
- Costs of losses
  - by subcomponent
  - in aggregate
- Costs of intervention strategies
- Program design
- System-specific

economic analysis

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



Component Analysis of Real Losses

Real Losses =

Background Leakage

- Pressure reduction
- Main & service replacement
- Reduce # of joints and fittings

Unreported Leakage

- Pressure reduction
- Main & service replacement
- Reduce # of joints and fittings
- Proactive leak detection

Reported Leakage

- Pressure reduction
- Main & service replacement
- Optimized repair time

Component Analysis of Real Losses

Background Leakage

- Pressure reduction
- Main & service replacement
- Reduce # of joints and fittings

Unreported Leakage

- Pressure reduction
- Main & service replacement
- Reduce # of joints and fittings
- Proactive leak detection

Reported Leakage

- Pressure reduction
- Main & service replacement
- Optimized repair time

Proactive Metering Testing & Maintenance

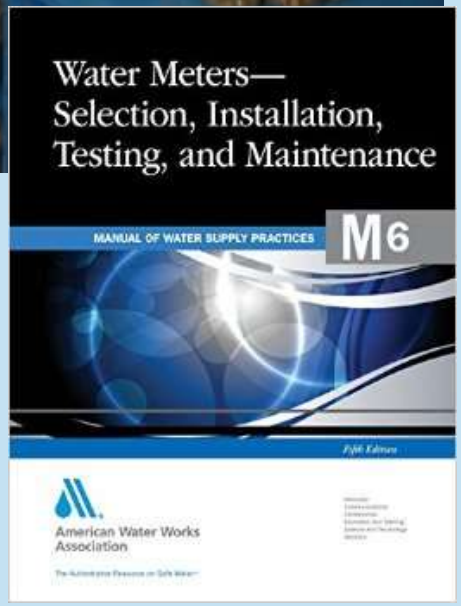
- Radio read conversion
- Meter Testing
- Meter remediation based on payback Analysis

Historic Large Meter Testing Program

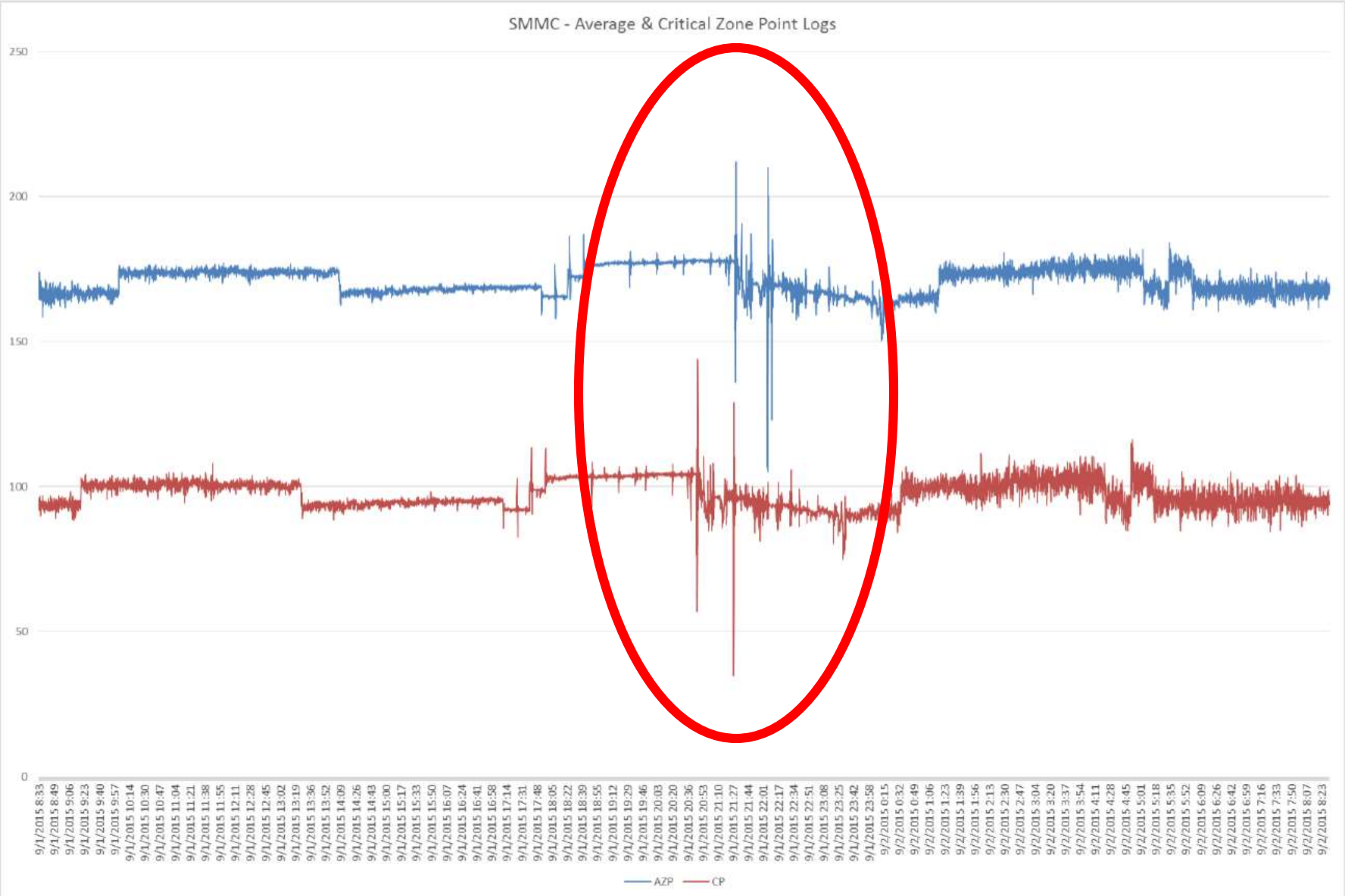
METERING

Established in 2012

- -Meter selections from payback analysis
- -Establishment of testing protocol (M6)
- -Field apparatus
- -Getting crews setup & training



Pressure Optimization



Pressure Management

PRESSURE MANAGEMENT: REDUCTION OF EXCESS AVERAGE AND MAXIMUM PRESSURES						
CONSERVATION BENEFITS		WATER UTILITY BENEFITS			CUSTOMER BENEFITS	
REDUCED FLOW RATES		REDUCED FREQUENCY OF BURSTS AND LEAKS				
REDUCED CONSUMPTION	REDUCED FLOW RATES OF LEAKS AND BURSTS	REDUCED REPAIR COSTS, MAINS & SERVICES	DEFERRED RENEWALS AND EXTENDED ASSET LIFE	REDUCED COST OF ACTIVE LEAKAGE CONTROL	FEWER CUSTOMER COMPLAINTS	FEWER PROBLEMS ON CUSTOMER PLUMBING & APPLIANCES

Source: Fantozzi & Lambert, 2010

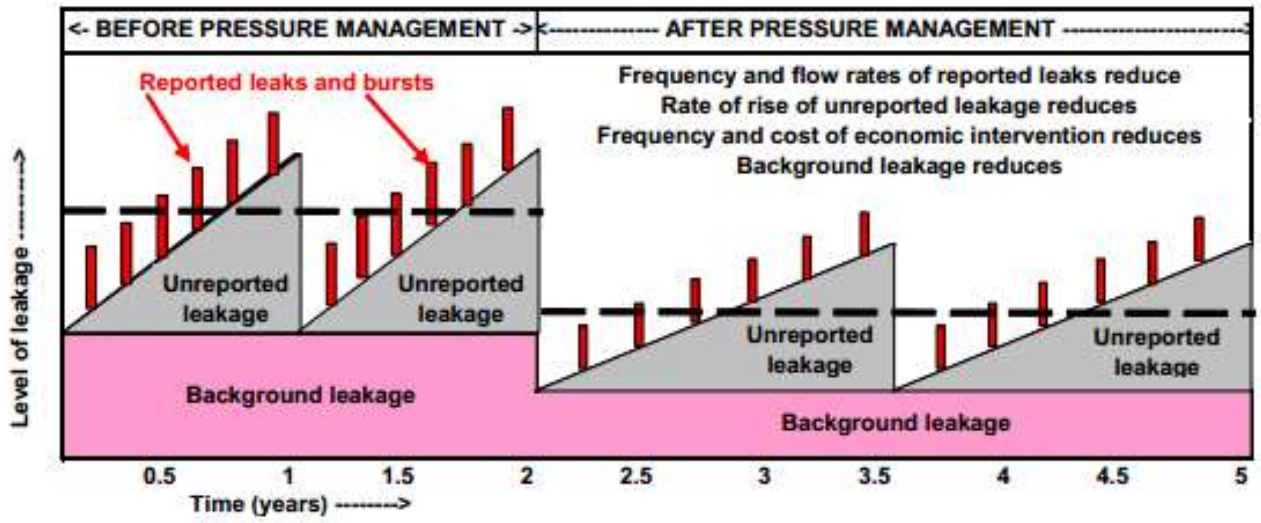
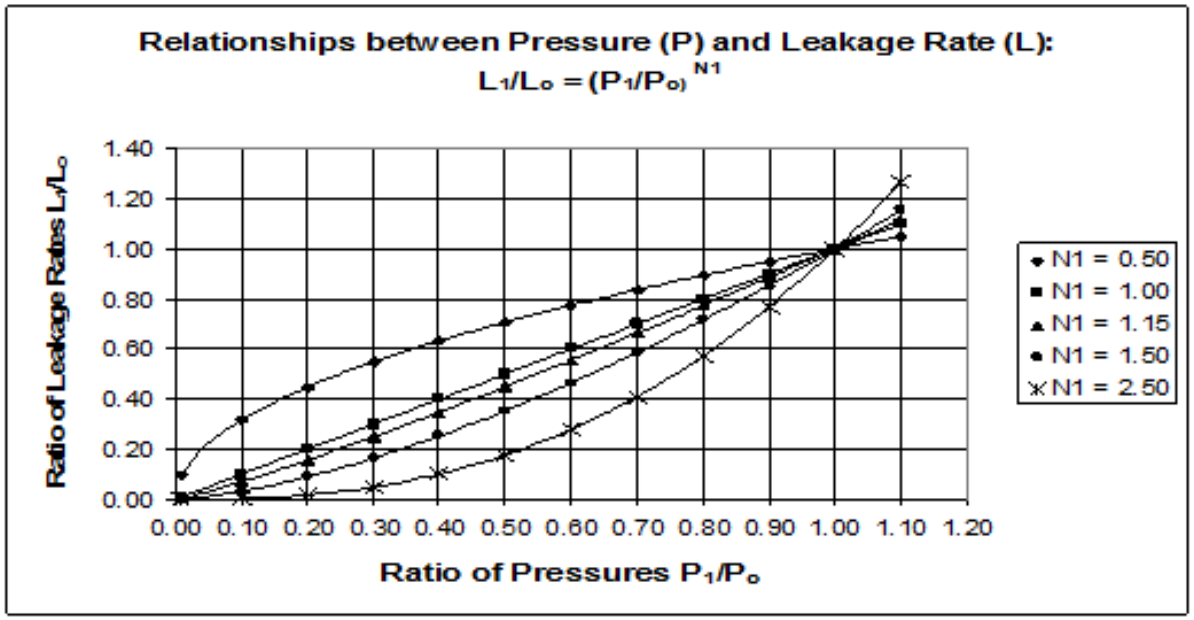


Figure 1: Influence of pressure management on BABE components of Real Losses
Source: Fantozzi & Lambert (2007)

Pressure Management

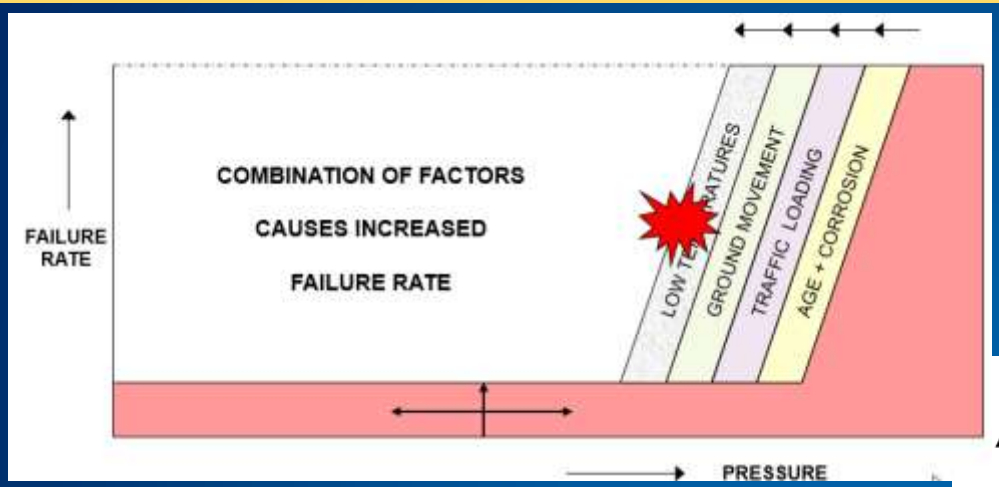
FAVAD – Fixed and Variable Area Discharges

- John May (UK) – 1994
- N1 – Exponent as a function of pipe type
- $Leakage_{Post}/Leakage_{Pre} = (Pressure_{Post}/Pressure_{Pre})^{N1}$



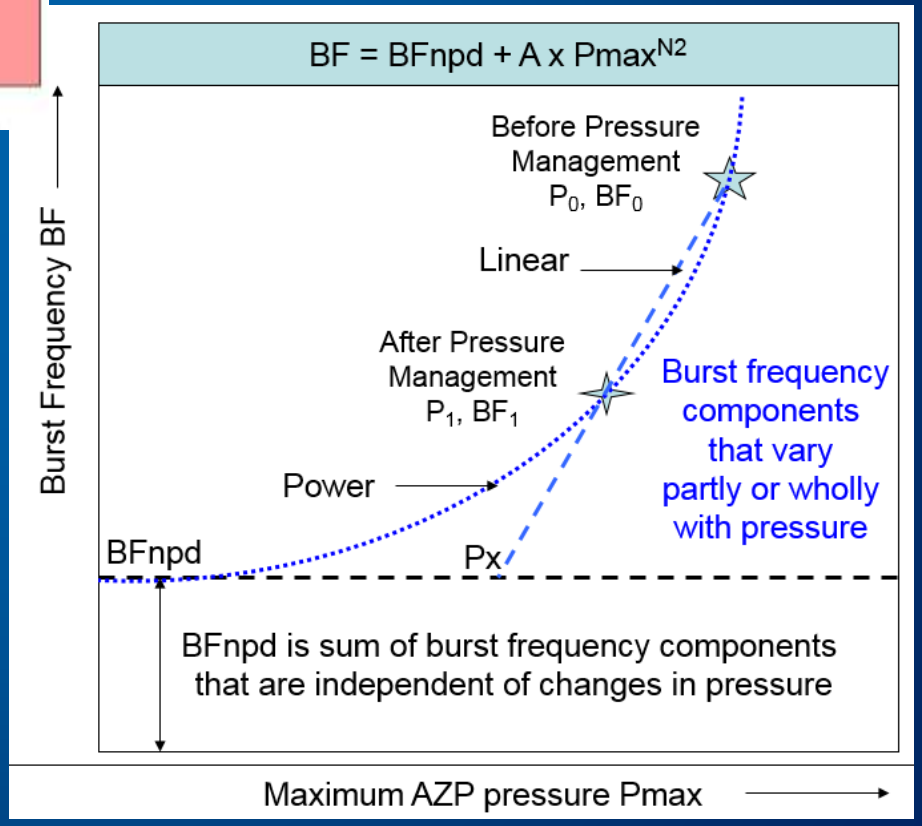
Source: Lambert 2003

Pressure Management



Pressure & Break Relationship – The 'Straw that Breaks the Camel's Back' Concept

- What causes Breaks?
- Mains & Services
- Unavoidable Break Frequency
- Consumption/Pressure Relationship



Source: Thorton & Lambert 2006

Pressure Management

Water Pumped into Zone

Pressure Zone #1
Avg. Pressure 100 psi
Total Consumption = 500 MG/year
Breaks/year = 15
Annual Real Losses = 50 MG/year
Total Water Pumped = 550 MG/year @ 100 psi

Critical Point – Minimum Delivery Pressure

Real Losses = Leaks

After Pressure Management

Avg. Pressure 75 psi
Total Consumption = 500 MG/year
Breaks/year = 10
Annual Real Losses = 40 MG/year

Total Water Pumped = 540 MG/year @ 75 psi

Less Water Pumped = Energy Saved
Water Pumped at lower pressure = Energy Saved

Operational Costs

Reduced Production		
Variable Production Cost	$ 336	$/MG
Real Loss Reduction	435.34	MG/year
Annual Cost Savings	$ 146,249	
Reduced Pumping		
Energy Cost	$ 0.08	$/KW-Hr
Energy Reduction	9,051	KW-Hr/day
Daily Energy Savings	$ 724	$/day
Annual Energy Savings	$ 264,293	$/year

Billing System Improvements

utbilmtr
- * (All Columns)
- utbmt_utbls_key
- utbmt_type
- utbmt_act_dmd
- utbmt_act_kvar
- utbmt_act_read
- utbmt_act_usage
- utbmt_billed_dmd
- utbmt_billed_kvar
- utbmt_billed_usage
- utbmt_dmd_multi
- utbmt_dmd_pwr_fact
- utbmt_dummy_meter
- utbmt_filler
- utbmt_meter_read

utactmst
- * (All Columns)
- utacm_key
- utacm_account
- utacm_start_date
- utacm_stop_date
- utacm_type
- utacm_parcel
- utacm_prop_desc
- utacm_district

cplocmst
- * (All Columns)
- cplm_id
- cplm_loc_seq
- cplm_parcel_id
- cplm_loc_no
- cplm_loc_no_suff
- cplm_pre_dir
- cplm_street_code
- cplm_street

utactcid
- * (All Columns)
- utacd_key
- utacd_account
- utacd_cid
- utacd_utacm_key
- utacd_cid_addr
- utacd_start_date
- utacd_stop_date
- utacd_relation
- utacd_convert
- utacd_filler
- utacd_hold_bill

tCustGroup
- * (All Columns)
- RecordKey
- Customer Group

arcstcid
- * (All Columns)
- arcs_acct
- arcs_name1

utmtrmst
- * (All Columns)
- utmtm_key
- utmtm_man_code
- utmtm_meter
- utmtm_status

utmtrdtl
- * (All Columns)
- utmtd_key
- utmtd_utmtm_key
- utmtd_seq
- utmtd_device_code

Column	Alias	Table	Outp...	Sort Type	Sort Order	Filter	Or...	Or...	Or...
utbmt_type	[Meter ...	utbilmtr	☑						
utbmt_act_read	[Actual...	utbilmtr	☑						

```
SELECT DISTINCT
    dbo.utbilmtr.utbmt_type AS [Meter Type?], dbo.utbilmtr.utbmt_act_read AS [Actual Read], dbo.utbilmtr.utbmt_act_usage AS [Actual Usage], dbo.utbilmtr.utbmt_billed_usag
    CAST(dbo.utbilmtr.utbmt_read_date AS date) AS [Read Date], DATEPART(YYYY, dbo.utbilmtr.utbmt_read_date) AS [Read Year], DATEPART(MM, dbo.utbilmtr.utbmt_read_da
    dbo.utbilmtr.utbmt_read_date) AS [Read Day], CAST(dbo.utbilmtr.utbmt_read_date_p AS date) AS [Previous Read Date], dbo.utbilmtr.utbmt_act_read_p AS [Previous Read],
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    S X], dbo.cplocmst.cplm_gis_y AS [Loc GIS Y], tCustGroup.[Customer Group], dbo.arcstcid.arcs_
```
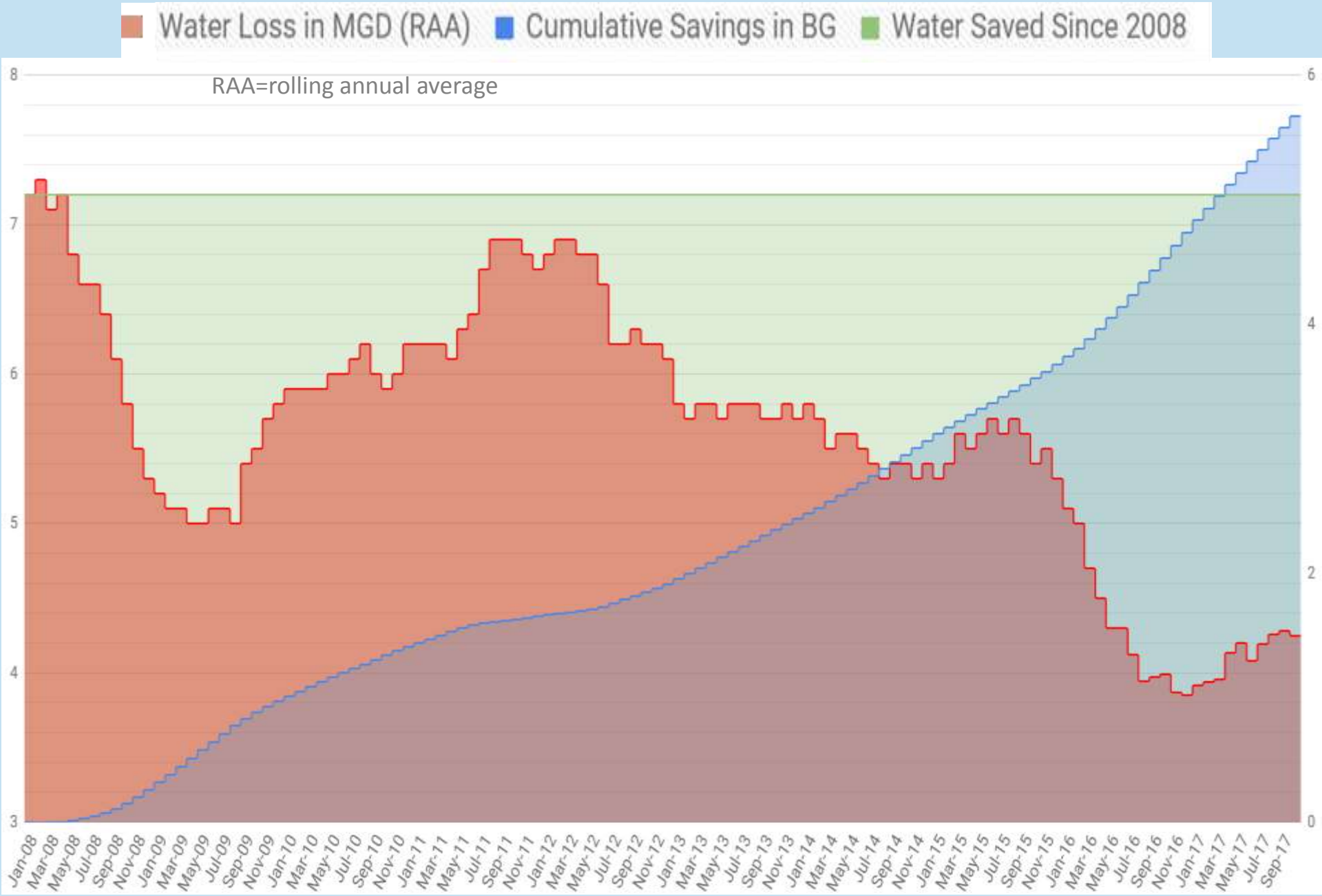

NRW Program – key points

- Challenges
  - Change of Culture
    - In department and out of department
  - Relating NRW Projects to CIP
  - Keeping Staff Focused on NRW

- Advantages
  - Decrease in Water Loss
  - Team focus – Employee Engagement
  - Improved Communications
  - Improved Business Processes
  - Good Media Answer


Water Loss in MGD (RAA)
Cumulative Savings in BG
Water Saved Since 2008
RAA=rolling annual average
8
7
6
5
4
3
6
4
2
0
Jan-08
Mar-08
May-08
Jul-08
Sep-08
Nov-08
Jan-09
Mar-09
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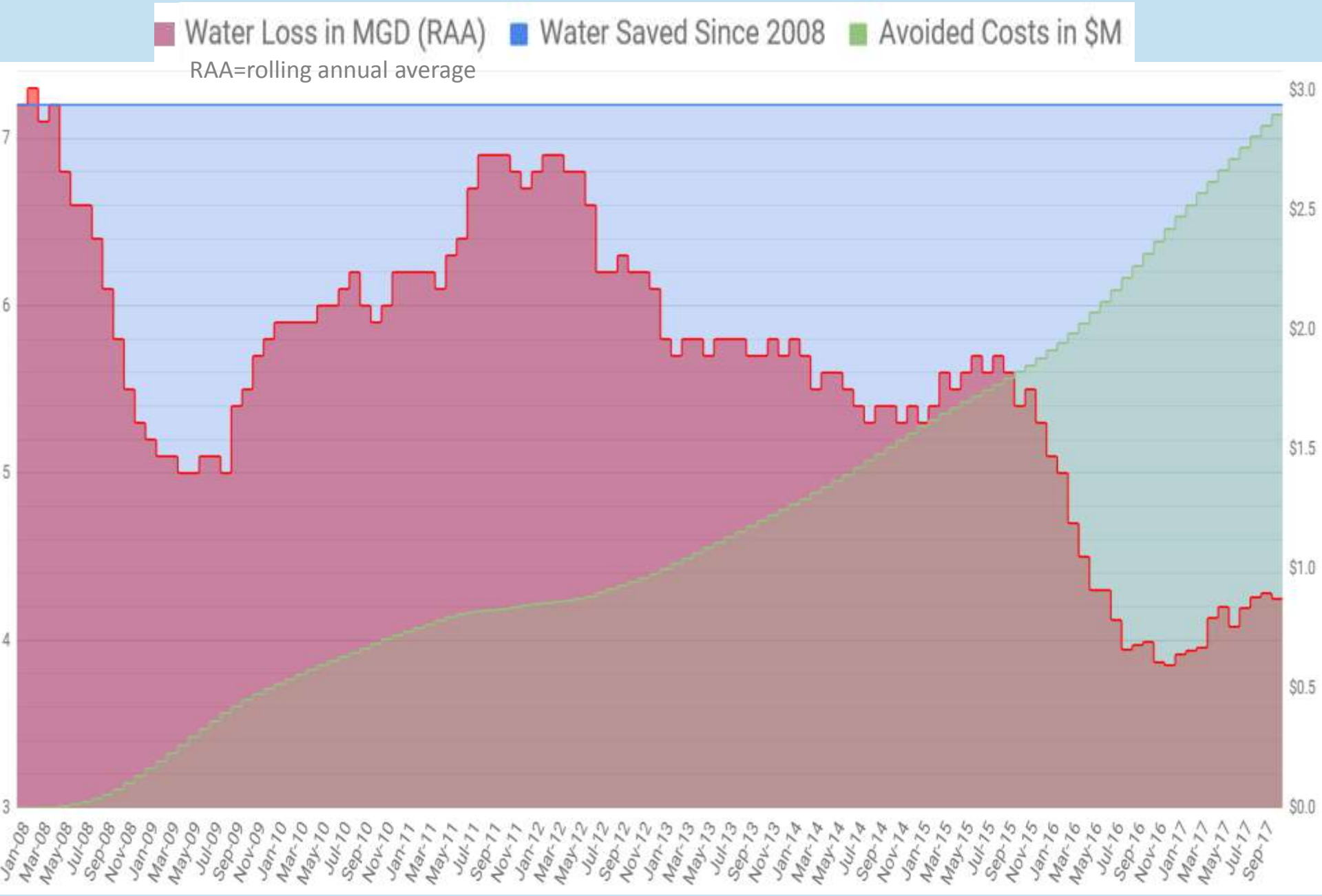
Water Loss in MGD (RAA)
Water Saved Since 2008
Avoided Costs in $M
RAA=rolling annual average
7
6
5
4
3
$3.0
$2.5
$2.0
$1.5
$1.0
$0.5
$0.0
Jan-08
Mar-08
May-08
Jul-08
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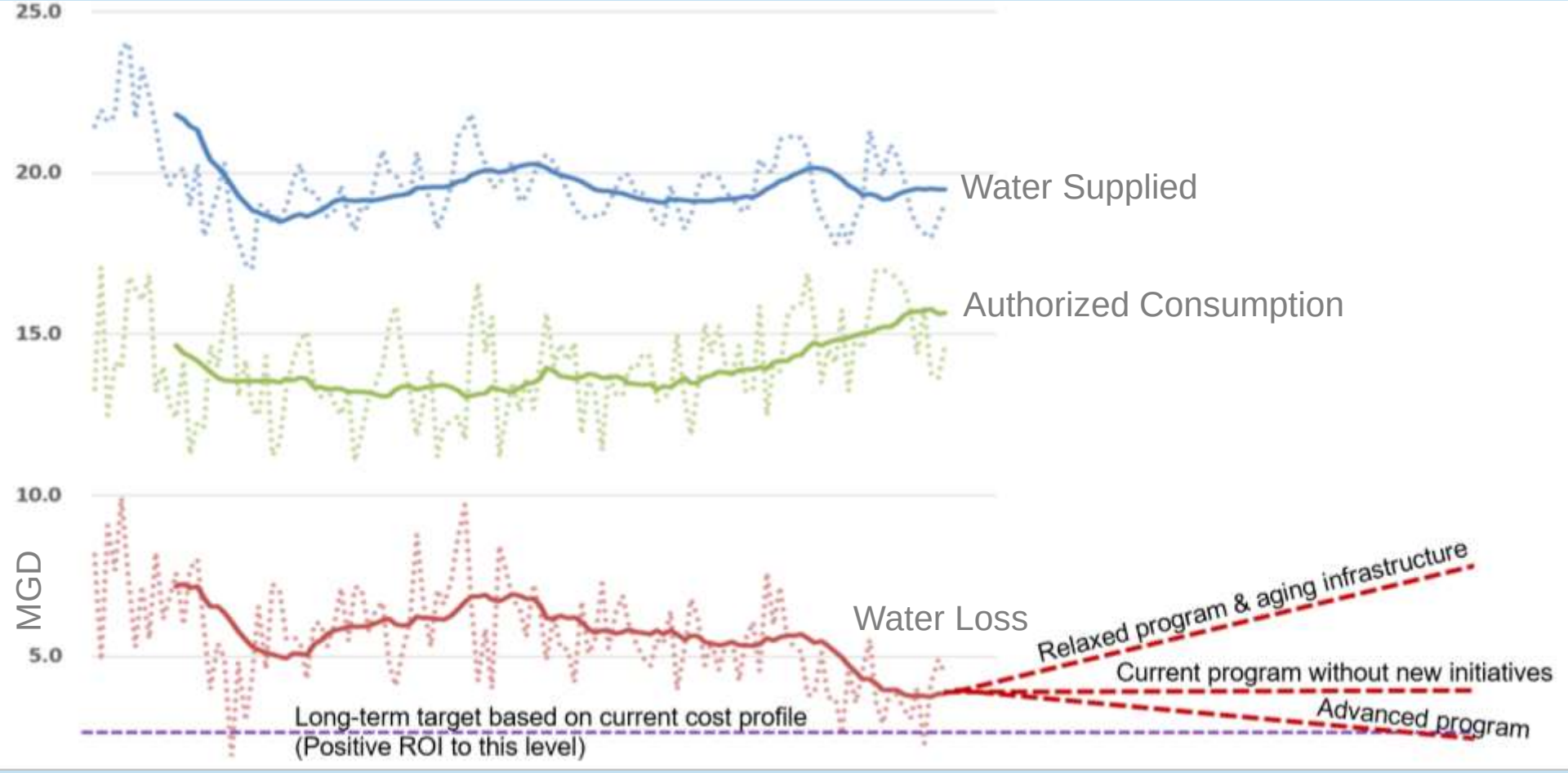
The Path Forward



Discussion

1. What is Pennsylvania's driver?
2. Utility survey – Who is doing Audits?
3. Who is currently doing Leak Detection?
4. Is there interest in a Pilot?

Asheville, NC – 10 years of Water Loss Control

… and Counting

CAVANAUGH
Stewardship Through Innovation

M. Steve Cavanaugh, Jr., PE
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May 10, 2018

Pennsylvania AWWA
American Water Works Association