



Water Loss Audits Using the AWWA M36 Software – Creating and Implementing an Audit for Your System

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What we will learn

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- What is a Water Audit?
- What are the Benefits to annual water audits?
- What triggers voluntary & required water audits?
- How to conduct a water audit using AWWA M36 software
- How to interpret and report data validity
- How to interpret audit results – Volumes and Values
- How to interpret results from AWWA M36 software
- How to use results to implement corrective actions



Acknowledgements

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- Majority of original content developed by Cavanaugh & Associates and SWEFC under contract to NMED-DWB
- Further content added by DWB Technical Services staff:
 - Michael Peterson
 - Peter Nathanson
 - Brian Barrick
 - Martin Torres



Old Terminology – no longer used

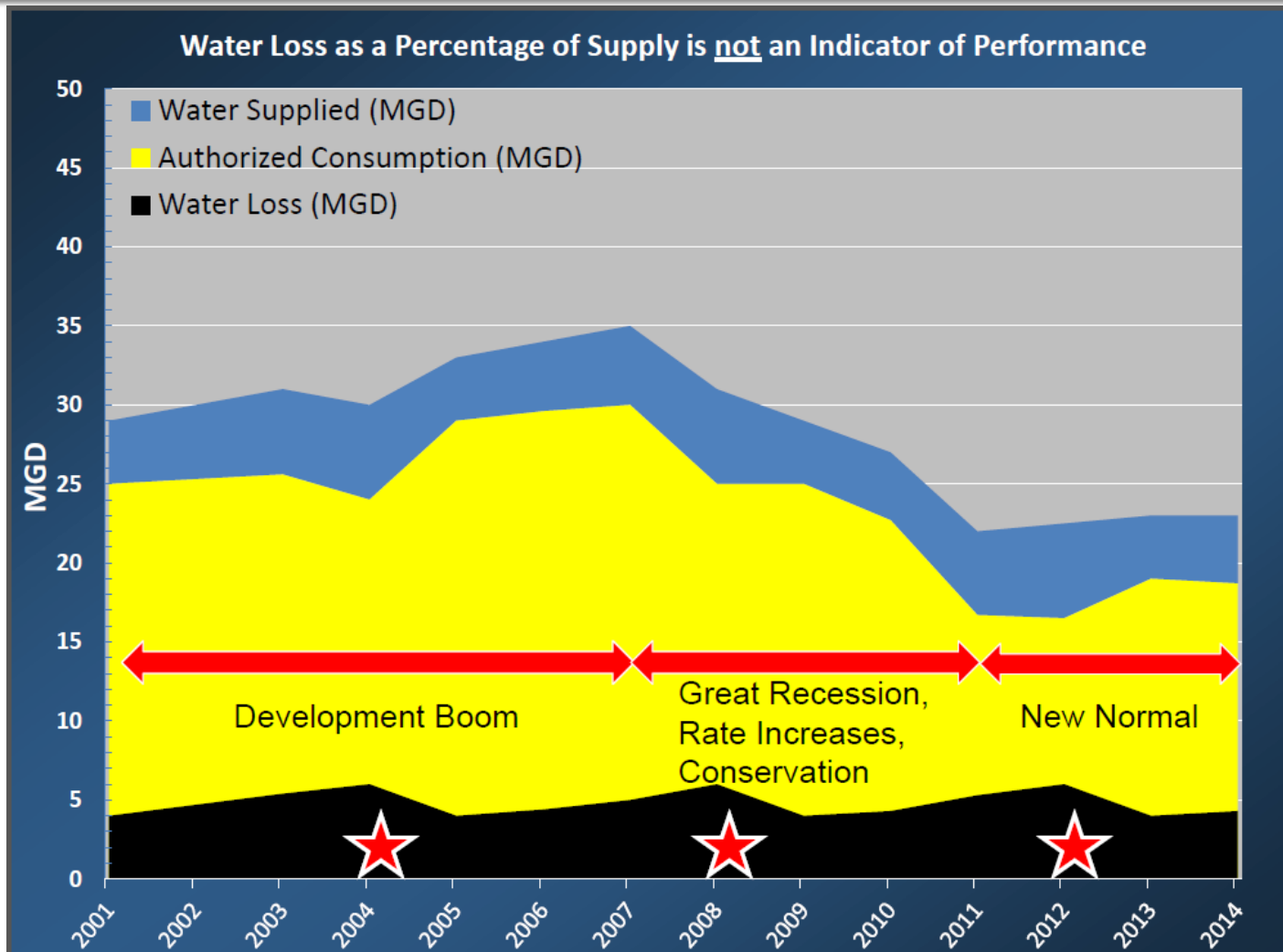
4

- Unaccounted For Water
 - Fails to segregate water loss into its components for effective management
 - Unreliable indicator of performance
- Unaccounted for Water Percentage
 - <10 % acceptable
 - 10-15% needs attention
 - > 15% needs immediate attention



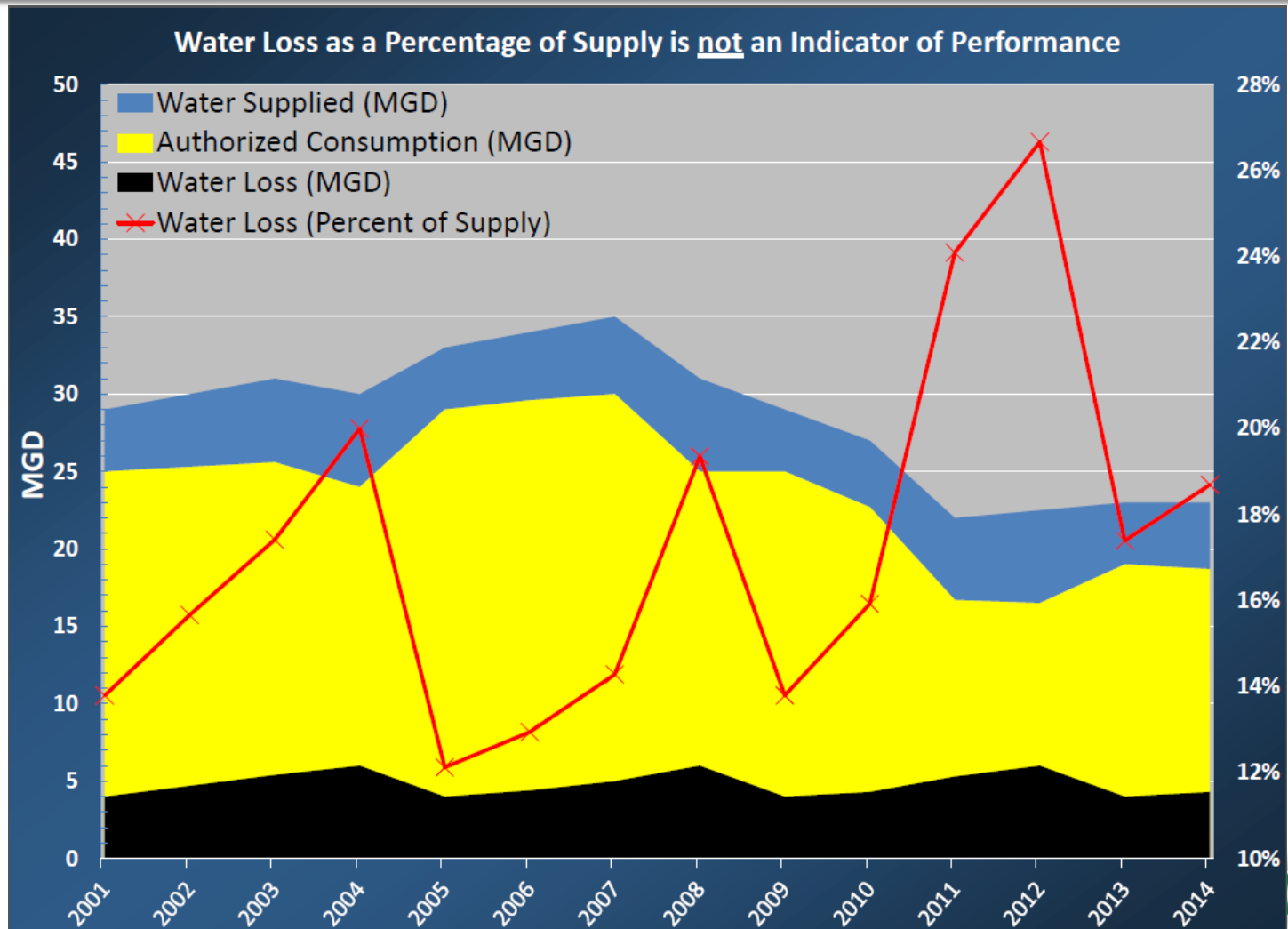
Unaccounted for Water Percentage

5



Unaccounted for Water Percentage

6



What is the Water Balance?

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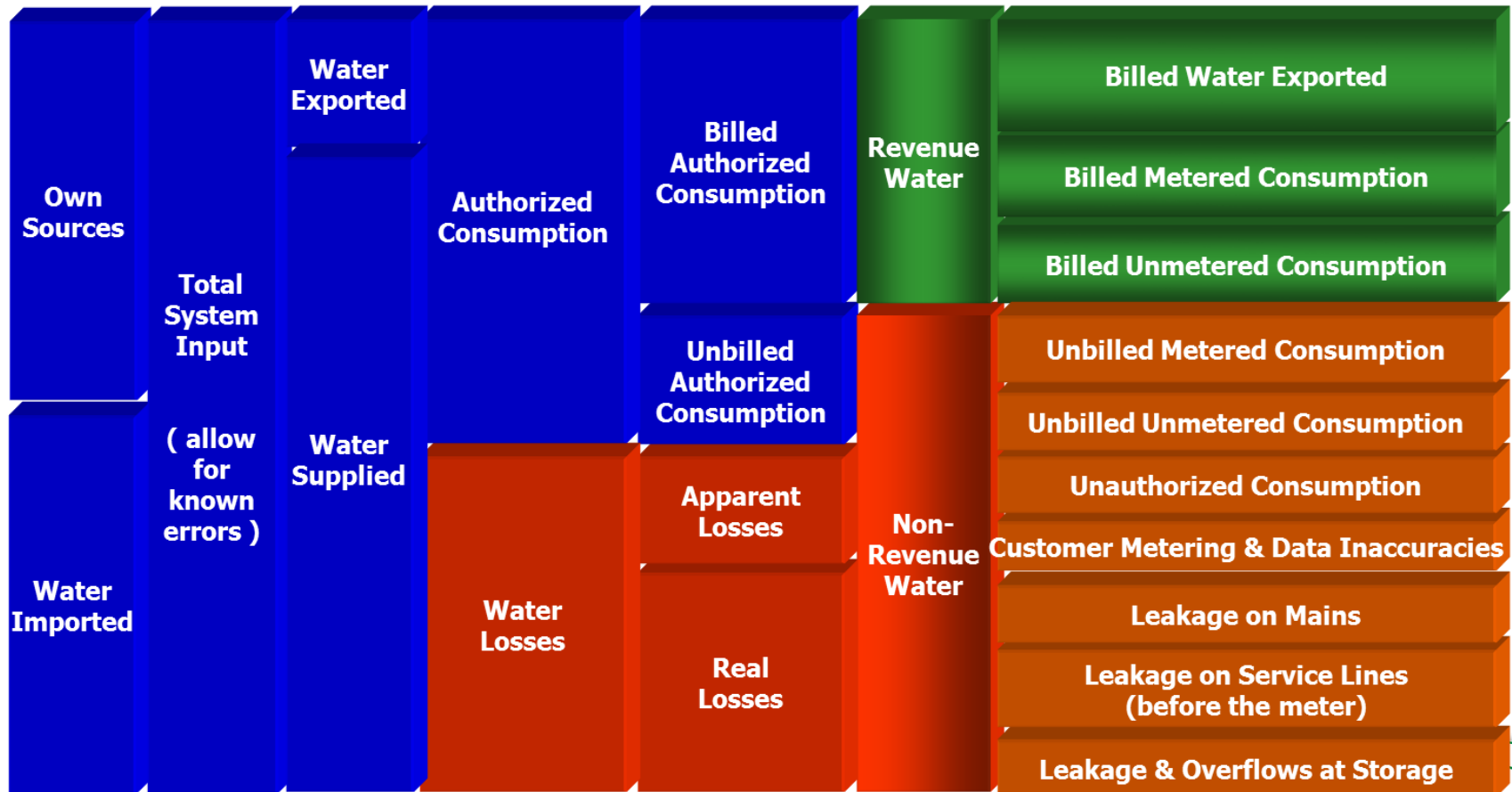
In this section you will learn to:

- 1) Utilize the Water Balance
- 2) Separate Total Water Loss into Real and Apparent Loss
- 3) Separate Real and Apparent Loss into their sub-components
- 4) Use metrics in units of Volume, Value, & Validity



AWWA Water Balance

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Billed Water Exported

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- Water exported to consecutive connection systems sold at a wholesale rate
- Required data:
 - ▣ Volume (annual & monthly)
 - ▣ Revenue (annual & monthly)
- Data issues:
 - ▣ Metered or estimated water consumption?
 - ▣ Metering inaccuracies
 - ▣ Data transcription



Billed metered consumption

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- Water sold at retail rate to customers/members of the water system
- Required Data:
 - ▣ Rate Structure
 - ▣ Volume sold (annual & monthly)
 - ▣ Revenue (annual & monthly)
- Data issues:
 - ▣ Metered or estimated consumption?
 - ▣ Meter inaccuracy
 - ▣ Data transcription



Billed Unmetered Consumption

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- Flat-rate, non-metered customer (Construction contracts, Fire Department)
- Required data:
 - ▣ Estimated volume consumed (annual & monthly)
 - ▣ Revenue (annual & monthly)
- Data issues:
 - ▣ No meters
 - ▣ Estimated volumes



Unbilled Metered Consumption

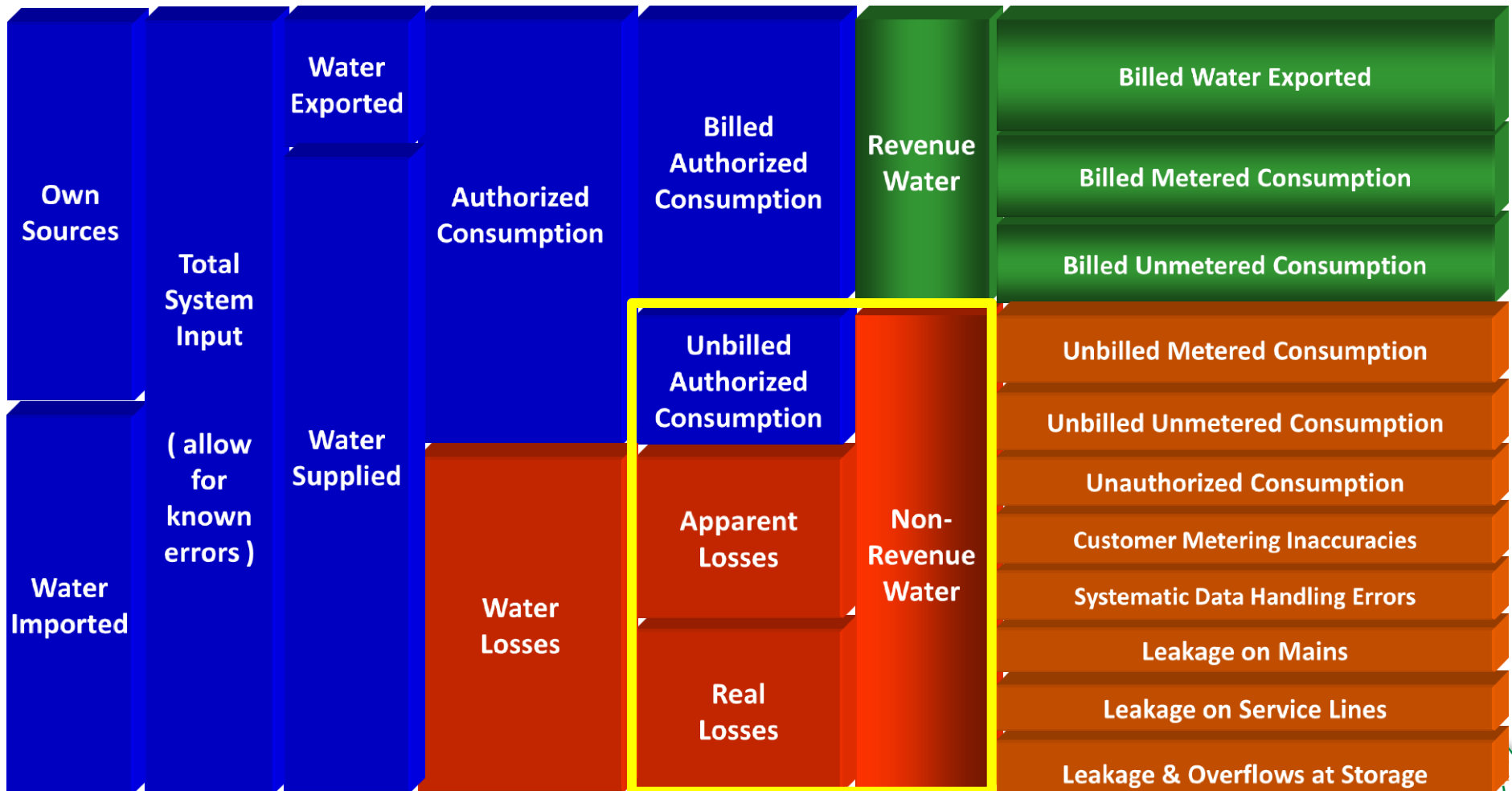
12

- Water that is delivered to customers who don't pay, but volume consumed is recorded
- Required Data
 - Usage (annual & monthly)
 - Fire Department usage, if Fire Department uses meters during training & suppression (annual & monthly)
- Data issues
 - Meter inaccuracy



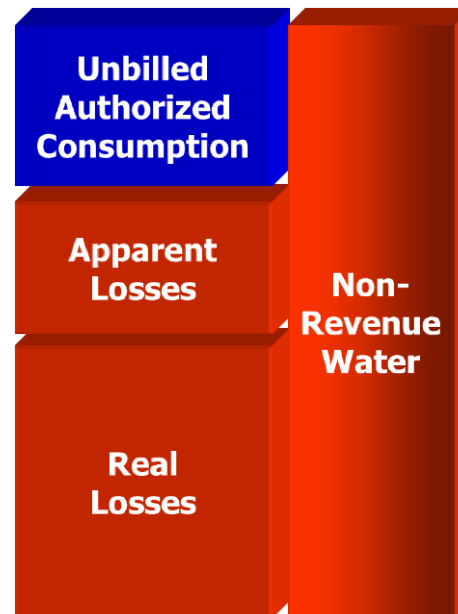
AWWA Water Balance

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AWWA Water Balance

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Non-Revenue Water

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- Unbilled Authorized:
 - ▣ Fire Department
 - ▣ Operational Flushing
- Apparent Losses:
 - ▣ Non-physical/revenue loss
 - ▣ Meter inaccuracy, billing issues, theft
- Real Losses:
 - ▣ Physical losses
 - ▣ Leaks, Storage overflow

Unbilled
Authorized
Consumption



Apparent
Losses



Real
Losses



Non-
Revenue
Water



Apparent Losses - Unbilled unmetered Consumption

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- Water delivered to customers that do not pay for water service; Fire suppression
- Required Data:
 - Estimates of volume used for fire services (annual & monthly)
 - Estimates of volume supplied to customers (annual & monthly)
 - Operational Flushing volumes if not metered (annual & monthly)
- Data issues:
 - Estimates, not known data



Apparent Losses - Unauthorized Consumption

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- Includes water that is taken against the policies of the water utility (Illegal connections, open bypasses, misuse of fire hydrants, theft)
- Required data:
 - ▣ Examine occurrences of unauthorized consumption, obtain quantities.
- Data issues:
 - ▣ Estimates
 - ▣ Poor records for basis of estimating



Apparent Losses - Customer metering & data inaccuracies

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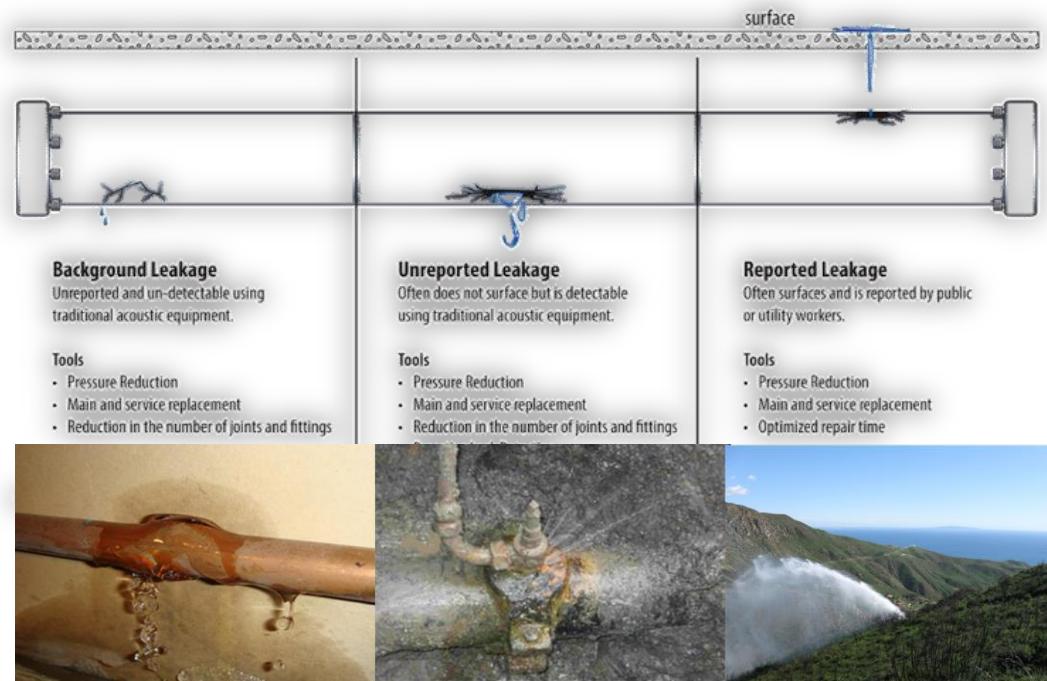
- Customer meter considerations
 - ▣ Meter age?
 - ▣ Testing/calibration policy?
 - ▣ Replacement policy?
 - ▣ Is the meter the right meter for the job?
- Required Data
 - ▣ Average customer meter inaccuracy (%), weighted by meter size if available (annual)\
- Data issues
 - ▣ Data transcription



Real Losses - Leakage on Mains

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- Leakage at joints or along pipe sections of distribution main
- Required data:
 - ▣ Estimates of leakage
- Data Issues
 - ▣ Estimates, data transcription



Real Losses - Leakage along service lines

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- Leakage along service connection lines
- Data requirements:
 - Estimated average loss on service connection between distribution main and customer meter, multiplied by amount of connections
 - Average length of service line
- Data issues:
 - Estimation
 - Data not routinely collected



Real Losses - Leakage & overflow at storage

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- Leakage from storage facilities due to:
 - ▣ Overflow (check SCADA/pressure switches to control pump)
 - ▣ Inadequate facility walls
 - ▣ Inadequate facility foundation
- Data requirements:
 - ▣ Estimated volume lost from storage leakage (annual)
- Data issues:
 - ▣ Estimates
 - ▣ Data not routinely collected



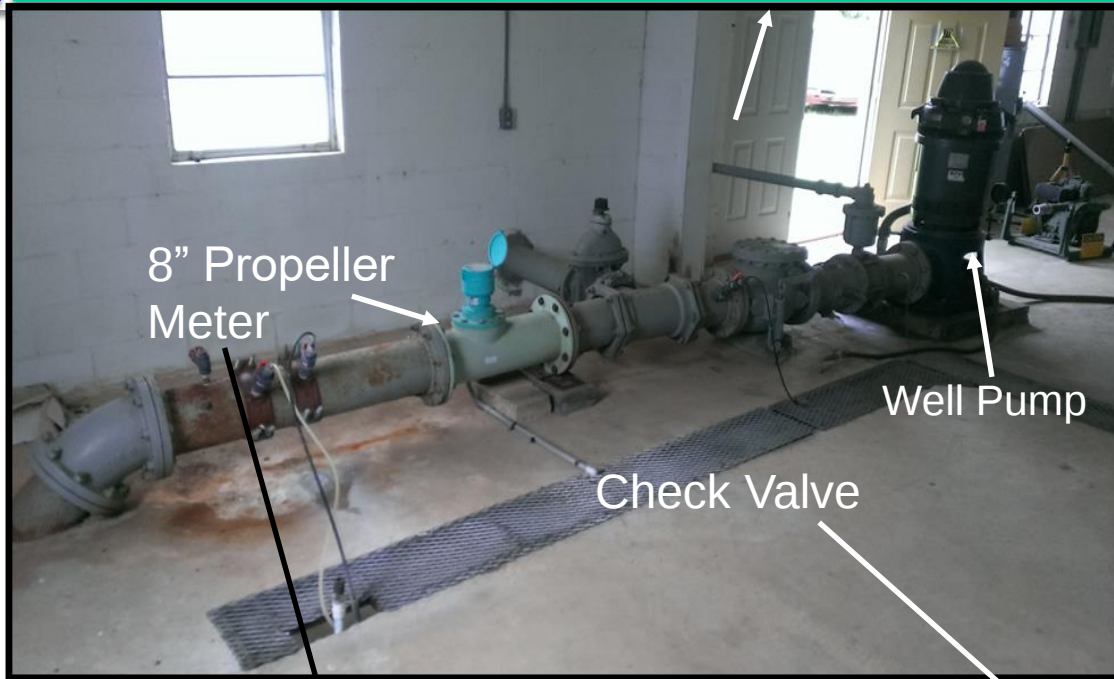
Meter Inaccuracy

22



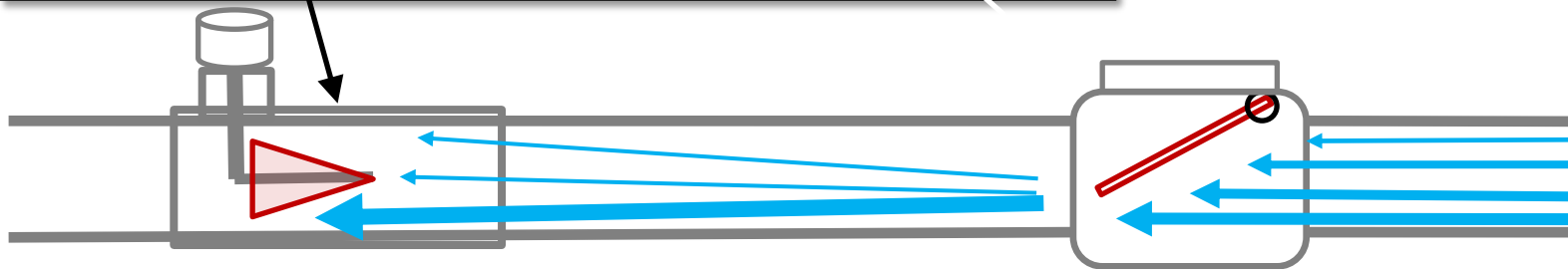
Meter Inaccuracy

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Accuracy results from MFR test bench: 99.5%

Accuracy results from in-situ test: 142.2%



Courtesy MESCO



Benefits of completing annual audits

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- Increased knowledge of water system
- Metric to determine areas to focus to improve overall system performance
- Improved future asset and maintenance project planning
- Streamline billing & operations



Why should our PWS do a Water Loss Audit?

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- Water Resources Management Concerns
 - ▣ Only water needed for usage is withdrawn
 - ▣ Limit need for additional water resources
 - ▣ Ease water restrictions
 - ▣ Serve additional customers without expanding source
- Financial Concerns
 - ▣ Recover revenue from customers that have been underpaying, or not paying
 - ▣ Reduce operational costs for pumping, chemical treatment and maintenance
 - ▣ Reduce liability



Why should our PWS do a Water Loss Audit?

2

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□ Operational Concerns

- ▣ Increased knowledge of distribution system
- ▣ Basis for optimized operations
- ▣ Safeguard public health and safety
- ▣ Improved public relations
- ▣ Reduced disruption to customers

□ System Integrity

- ▣ Improved data integrity
- ▣ Review of customer billing practices and procedures
- ▣ Prevention of contamination



Voluntary Triggers

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- PWS suspects major water loss and:
 - ▣ Wants to physically look for leaks (post-holing)
 - ▣ Wants to request public funding for distribution system rehabilitation
- DWB/SWEFC can provide assistance completing water audit



Required Triggers

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- DWB
 - ▣ Enforcement, Case-by-case basis
- NMOSE
 - ▣ Water Conservation Planning Guide for Public Water Suppliers



How to Conduct Audit using AWWA M36 software

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What information do we need to complete a water audit? (1 of 4)

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- Master/Source Meter volumes (annual & monthly)
 - ▣ Include master meters for bulk purchase or wholesale
- Customer meter data (annual & monthly)
 - ▣ Volume of water sold @ retail rate
 - ▣ Volume of water sold @ wholesale rate
- List of unbilled customers (metered & non-metered),
Number of active & inactive service connections



What information do we need to complete a water audit? (2 of 4)

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- Rate Structure
 - ▣ Volume of water sold @ retail rate
 - ▣ Volume of water sold @ wholesale rate
- Total annual cost of operating water system (salaries, vehicles, maintenance, power, chemicals, etc.)
- Total annual cost for power and chemicals for water production/purification/disinfection
- Total length of distribution mains



What information do we need to complete a water audit? (3 of 4)

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- Occurrence of leaks (annual & monthly)
- Source/Master Meter info:
 - ▣ Age
 - ▣ Date of last calibration
 - ▣ Calibration records if available
- Customer Meter info:
 - ▣ Average age
 - ▣ Testing/replacement policy



What information do we need to complete a water audit? (4 of 4)

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- Policies/Procedures for:
 - ▣ Source meters
 - ▣ Customer meters,
 - ▣ Meter replacement policy
 - ▣ Operational policies
 - ▣ Financial & recordkeeping
- Normal practices relating to flushing for operators, fire hydrant flushing, fire suppression logs.



AWWA Free Water Loss Audit Software

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- Standard Data Collection tool in North America
- Inputs
 - 13 volume inputs
 - 5 system attribute inputs
 - 3 cost inputs
- After Default or n/a's
 - 10-12 inputs to actually deal with

<https://www.awwa.org/home/awwa-news-details/articleid/2641/awwa-free-water-audit-software-version-5-0-now-available.aspx>

AWWA Free Water Audit Software: Reporting Worksheet

WAS v5.0
American Water Works Association
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Water Audit Report for: **County Water Company**
Reporting Year: **2013** 1/2013 - 12/2013

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: MILLION GALLONS (US) 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

Volume from own sources: 5 3,481,590 MG/yr
Water imported: 10 779,762 MG/yr
Water exported: na 0.000 MG/yr

WATER SUPPLIED: 4,402,160 MG/yr

Master Meter and Supply Error Adjustments

Point: 4 Value: -136,890 MG/yr
Point: 10 Value: -0.50% MG/yr

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

AUTHORIZED CONSUMPTION

Billed metered: 7 3,258,200 MG/yr
Billed unmetered: na 0.000 MG/yr
Unbilled metered: 3 15,420 MG/yr
Unbilled unmetered: 8 183,820 MG/yr

Unbilled Unmetered volume entered is greater than the recommended default value

AUTHORIZED CONSUMPTION: 3,457,440 MG/yr

WATER LOSSES (Water Supplied - Authorized Consumption)

944,720 MG/yr

Apparent Losses

Unauthorized consumption: 8 11,005 MG/yr
Default option selected for unauthorized consumption - a grading of 5 is applied but not displayed

Customer metering inaccuracies: 8 164,300 MG/yr
Systematic data handling errors: 6 32,920 MG/yr

Apparent Losses: 1 208,225 MG/yr

Real Losses (Current Annual Real Losses or CAPL)

Real Losses = Water Losses - Apparent Losses: 7 736,495 MG/yr

WATER LOSSES: 944,720 MG/yr

NON-REVENUE WATER

NON-REVENUE WATER: 7 1,143,960 MG/yr

Water Losses + Unbilled Metered + Unbilled Unmetered

SYSTEM DATA

Length of mains: 4 256.3 miles
Number of active AND inactive service connections: 4 12,196
Service connection density: 48 conn./mile main

Are customer meters typically located at the curbstop or property line? No
Average length of customer service line: 5 18.0 ft (length of service line, beyond the property boundary, that is the responsibility of the utility)

Average operating pressure: 3 65.0 psi

COST DATA

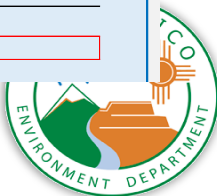
Total annual cost of operating water system: 9 \$9,600,000 \$/Year
Customer retail unit cost (applied to Apparent Losses): 10 \$3.95 \$/1000 gallons (US)
Variable production cost (applied to Real Losses): 9 \$190.00 \$/million gallons

Use Customer Retail Unit Cost to value real losses

WATER AUDIT DATA VALIDITY SCORE:

*** YOUR SCORE IS: 66 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



Develop the inputs

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AWWA Free Water Audit Software: Reporting Worksheet WAS v5.0
American Water Works Association.
Copyright © 2014, All Rights Reserved.

Water Audit Report for: **McRae/Water (2710003)**
Reporting Year: **2014** **1/2014 - 12/2014**

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: MILLION GALLONS (US) 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

WATER SUPPLIED

			<----- Enter grading in column 'E' and 'J' ----->				Master Meter and Supply Error Adjustments	
					Pcnt:	Value:		
Volume from own sources:	+ ?	5	296.560	MG/Yr	+ ?	2	2.58%	MG/Yr
Water imported:	+ ?			MG/Yr	+ ?			MG/Yr
Water exported:	+ ?	4	37.500	MG/Yr	+ ?	2	-1.00%	MG/Yr
WATER SUPPLIED:			251.222	MG/Yr	Enter negative % or value for under-registration Enter positive % or value for over-registration			

□ Develop the input

- Trace from production reports
- Trace from meter testing reports

□ Data Validity

- Look for missing/extra volumes
- Mismatched timeframe
- Error adjustment should be weighted average



Develop the inputs

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AUTHORIZED CONSUMPTION

Billed metered:	+	?	5	209.067	MG/Yr
Billed unmetered:	+	?			MG/Yr
Unbilled metered:	+	?	5	3.188	MG/Yr
Unbilled unmetered:	+	?	3	3.775	MG/Yr

Unbilled Unmetered volume entered is greater than the recommended default value

AUTHORIZED CONSUMPTION:	?	216.030	MG/Yr
--------------------------------	---	----------------	-------

Click here: [?](#)
for help using option
buttons below

Pcnt:		Value:		MG/Yr
	☐	☒	3.775	

Use buttons to select
percentage of water
supplied

□ Data from:

- Billing reports
- Flushing tracker
- Fire department tracker

- Data validity Issues
 - Billing report inaccuracies
 - Double counting Water Exported in Billed Metered
 - Double counting Unbilled Metered consumption in Billed Metered Consumption
 - Including leaks/breaks in Unbilled Unmetered



Develop the inputs

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WATER LOSSES (Water Supplied - Authorized Consumption)		35.192 MG/Yr
Apparent Losses		
Unauthorized consumption:	+ <input <="" td="" type="button" value="?"/> <td>0.628 MG/Yr</td>	0.628 MG/Yr
Default option selected for unauthorized consumption - a grading of 5 is applied but not displayed		
Customer metering inaccuracies:	+ <input <="" td="" type="button" value="?"/> <td>7.130 MG/Yr</td>	7.130 MG/Yr
Systematic data handling errors:	+ <input <="" td="" type="button" value="?"/> <td>0.523 MG/Yr</td>	0.523 MG/Yr
Default option selected for Systematic data handling errors - a grading of 5 is applied but not displayed		

value

Pcnt: ☐ 0.25% ☐ 3.25% ☐ 0.25%

Value: MG/Yr

- Data from:
 - ▣ Billing/usage reports
 - ▣ Customer Meter calibration records
 - ▣ Approximate from meter system, age/condition
- Data Validity Issues
 - Customer meter calibration not always known, estimates



Develop the inputs

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SYSTEM DATA

Length of mains:	+	?	5	45.0	miles
Number of <u>active AND inactive</u> service connections:	+	?	8	1,800	
Service connection density:		?		40	conn./mile main
Are customer meters typically located at the curbside or property line?				Yes	(length of service line, <u>beyond</u> the property boundary, that is the responsibility of the utility)
Average length of customer service line:	+	?			
Average length of customer service line has been set to zero and a data grading score of 10 has been applied					
Average operating pressure:	+	?	1	50.0	psi

□ Data from:

- ▣ System maps
- ▣ Billing system/
database

- Data Validity Issues
 - Include hydrant leads in Length of Mains
 - Include inactive connections
 - Billing system reports customers, not connections



Develop the Inputs

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COST DATA

Total annual cost of operating water system:	+	?	9	\$565,184	\$/Year
Customer retail unit cost (applied to Apparent Losses):	+	?	5	\$2.69	\$/1000 gallons (US)
Variable production cost (applied to Real Losses):	+	?	5	\$202.97	\$/Million gallons ☐ Use Customer Retail Unit Cost to value

- Data from:
 - ▣ Operating budget
 - ▣ Rate structure
- Typical Ranges:
 - ▣ \$2-\$10/kgal for CRUC
 - ▣ \$200 - \$1000/MG for VPC (systems producing water)
- Data Validity Issues
 - Don't include wastewater costs if associated budget
 - Consider sewer rates in customer retail unit cost
 - Confusing units for variable production costs



How to conduct a Water Audit - Activity 1

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- Placeholder for Hands-On Activity #1
 - ▣ download and run initial water audit using Rockville WSC data
 - ▣ Follow-up using your own system data



Data Validity

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Data Grade Entry

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AWWA Free Water Audit Software: Reporting Worksheet

WASv5.0

American Water Works Association.
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- Click to access definition
- Click to add a comment

Water Audit Report for: **Watertown USA Water Treatment Works (XXXXYYYY)**
Reporting Year: **2014** **1/2014 - 12/2014**

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: **MILLION GALLONS (US) 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

WATER SUPPLIED

Volume from own sources: 95.206 MG/Yr
Water imported: MG/Yr
Water exported: MG/Yr

WATER SUPPLIED: **95.151** MG/Yr

AUTHORIZED CONSUMPTION

Billed metered: 80.408 MG/Yr
Billed unmetered: 0.048 MG/Yr
Unbilled metered: 1.250 MG/Yr
Unbilled unmetered: **1.450** MG/Yr

Unbilled Unmetered volume entered is greater than the recommended default value

AUTHORIZED CONSUMPTION: **83.156** MG/Yr

WATER LOSSES (Water Supplied - Authorized Consumption)

14.995 MG/Yr

Apparent Losses

Master Meter and Supply Error Adjustments

Pcnt: -3.00% Value: MG/Yr
 MG/Yr
 MG/Yr

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

Click here: for helping option buttons below

Pcnt: Value: **1.450** MG/Yr

Use buttons to select percentage of water supplied OR value

Data Grades



Data Grade Entry

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AWWA Free Water Audit Software
Reporting Worksheet

?

Click to access definition

+

Click to add a comment

Water Audit Report for: Watertown USA Water Treatment Works (X)
Reporting Year: 2011 1/2014 - 12/2014

WATER SUPPLIED:

Volume from own sources: 95.206 MG/Yr
Water imported: MG/Yr
Water exported: MG/Yr

WATER SUPPLIED: 98.151 MG/Yr

AUTHORIZED CONSUMPTION

Billed metered: 80.408 MG/Yr

Enter grading in column

0

Hover the cursor over the red triangle in the corner



Data Grade Entry

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At data grading for each input, determine the highest grade that meets or exceeds all criteria for that grade and all grades below

Master Meter and Supply Error Adjustments

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

Percent

Value

Time from own sources: + ? 5

Water imported: + ?

Water exported: + ?

WATER SUPPLIED:

Billed metered: + ? 6

Billed unmetered: + ? 8

Unbilled metered: + ? 1

Unbilled unmetered: + ? 2

Unmetered volume entered is greater than

PERMITS 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.

Data Grade criteria will show up in a pop-up box



Data Grade Entry

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All volumes to be entered as: MILLION GAL

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

<----- Enter grading

Volume from own sources:	+	?	5	95.206
Water imported:	+	?		
Water exported:	+	?		

et Performance Indicators Comments Water Balance Dashboard Grading Matrix Service Connection Diagram Defin

Note the comment on the water audit spreadsheet.



Data Grade Selection

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Volume from own sources

GRADE	✓	DESCRIPTION
1	✓	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.
1	✓	No regular meter accuracy testing or electronic calibration conducted.
2		25% - 50% of treated water production sources are metered; other sources estimated.
2		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.
4		Occasional meter accuracy testing or electronic calibration conducted.
5		Conditions between 4 and 6
6		At least 75% of treated water production sources metered sources.
6		Meter accuracy testing and/or electronic calibration conducted.
6		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,
8		Meter accuracy testing and electronic calibration of related instrumentation is conducted annually,
8		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,
10		Meter accuracy testing and electronic calibration of related instrumentation is conducted semi-annually, with less than 10% found outside of +/- 3% accuracy.
10		Procedures are reviewed by a third party knowledgeable in the M36 methodology

If you are able to check all the boxes move up.

Data Grade Selection

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Volume from own sources

GRADE	✓	DESCRIPTION
n/a		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
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 annually. 10% found outside of +/- 3% accuracy. Procedures are reviewed by a third party knowledgeable in the M36 methodology

If you aren't able to check all the boxes move down.



Data Grade Selection

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Volume from own sources

GRADE	✓	DESCRIPTION
n/a		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 conducted annually.
		Less than 25% of tested meters are found outside of +/- 3% accuracy.
7		Conditions between 6 and 8
		100% of treated water production sources are metered.
8		Meter accuracy testing and electronic calibration conducted annually.
		Less than 10% of meters are found outside of +/- 3% accuracy.
9		Conditions between 8 and 10
		100% of treated water production sources are metered.
10		Meter accuracy testing and electronic calibration conducted annually, with less than 10% found outside of +/- 3% accuracy.
		Procedures are reviewed by a third party k

If you are able to check all the boxes on one number and only some of the boxes on the number two above, choose the "conditions between..." box.

What is the *Right* Data Grade?

49

**ANY NUMBER AS LONG AS IT
ACURATELY REPRESENTS THE
TRUE SITUATION**



Data Grade Entry

50

 **AWWA Free Water Audit Software:
Reporting Worksheet** WAS v5.0
American Water Works Assoc
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[?](#) Click to access definition **Water Audit Report for:** Watertown USA Water Treatment Works (XXXXXXXXXX)
[+](#) Click to add a comment **Reporting Year:** 2014 1/2014 - 12/2014

WATER AUDIT DATA VALIDITY SCORE:

***** YOUR SCORE IS: 49 out of 100 *****

A weighted scale for the components of consumption and distribution loss 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: Unbilled metered

3: Customer metering inaccuracies

**Water Audit
Data Validity
Score**



If the Data Validity Score is below 50, What Should be the Response?

51

 **AWWA Free Water Audit Software:**
Reporting Worksheet

WAS v5.0
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Water Audit Report for: **Watertown USA Water Treatment Works (XXXXYYYY)**
Reporting Year: **2014** **1/2014 - 12/2014**

WATER AUDIT DATA VALIDITY SCORE:

***** YOUR SCORE IS: 49 out of 100 *****

A weighted scale for the components of consumption and distribution loss is used 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: Unbilled metered
- 3: Customer metering inaccuracies

**What
Response?**



Data Grade Entry

52

AWWA Free Water Audit Software:
Reporting Worksheet

WAS v5.0
American Water Works Assoc
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Water Audit Report for: **Watertown USA Water Treatment Works (XXXXYYYY)**
Reporting Year: **2014** **1/2014 - 12/2014**

WATER AUDIT DATA VALIDITY SCORE:

*** YOUR SCORE IS: 49 out of 100 ***

A weighted scale for the components of consumption and water loss is inc

PRIORITY AREAS FOR ATTENTION:

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

- 1: Volume from own sources
- 2: Unbilled metered
- 3: Customer metering inaccuracies

**Priority Areas for
Attention to
Increase Validity
Score**

**Note: The data grades do not have equal
value in the calculation of validity**



If Data Validity Score is greater than 50, What should be the response?

53

□ Evaluate the Metrics

***** YOUR WATER AUDIT DATA VALIDITY SCORE IS: 58 out of 100 *****

**>50 (validated
score)**

Non-revenue water as percent by volume of Water Supplied:	14.4%	
Non-revenue water as percent by cost of operating system:	26.9%	Real Losses valued at Variat

Apparent Losses per service connection per day: 22.31 gallons/connection/day

Real Losses per service connection per day: N/A gallons/connection/day

Real Losses per length of main per day*: 299.13 gallons/mile/day

Real Losses per service connection per day per psi pressure: N/A gallons/connection/day/psi

From Above, Real Losses = Current Annual Real Losses (CARL): 24.57 million gallons/year

? Infrastructure Leakage Index (ILI) [CARL/UARL]: 0.71

4 - 40

20 - 200

400 - 4000

2 - 10

is for systems with a low service connection density of less than 32 service connections/mile of pipeline



Check the Metrics

54

**** YOUR WATER AUDIT DATA VALIDITY SCORE IS: 51 out of 100 *****

Non-revenue water as percent by volume of Water Supplied:	26.0%	
Non-revenue water as percent by cost of operating system:	10.4%	Real Losses valued at Variable
Apparent Losses per service connection per day:	46.78	gallons/connection/day
Real Losses per service connection per day:	165.45	gallons/connection/day
Real Losses per length of main per day*:	N/A	
Real Losses per service connection per day per psi pressure:	2.55	gallons/connection/day/psi
From Above, Real Losses = Current Annual Real Losses (CARL):	736.49	million gallons/year
Infrastructure Leakage Index (ILI) [CARL/UARL]:	8.80	

4 – 40
20 – 200
400 – 4000
2 – 10

□ Metrics vs. Practices

- ▣ Inside the range – are they high, mid, or low?
- ▣ How does that compare to water loss management practices?



If Data Validity Score is greater than 50, What should be the response?

55

□ Evaluate the Metrics

***** YOUR WATER AUDIT DATA VALIDITY SCORE IS: 71 out of 100 *****

**>50 (validated
score)**

Non-revenue water as percent by volume of Water Supplied:	29.5%	
Non-revenue water as percent by cost of operating system:	38.7%	Real Losses valued at Vari
Apparent Losses per service connection per day:	10.92	gallons/connection/day
Real Losses per service connection per day:	N/A	gallons/connection/day
Real Losses per length of main per day*:	1,513.10	gallons/mile/day
Real Losses per service connection per day per psi pressure:	N/A	gallons/connection/day/psi
From Above, Real Losses = Current Annual Real Losses (CARL):	110.46	million gallons/year
? Infrastructure Leakage Index (ILI) [CARL/UARL]:	1.29	

for systems with a low service connection density of less than 32 service connections/mile of pipeline

**4 - 40
20 - 200
400 - 4000**

2 - 10



Data Validity – Activity 2

56

- Placeholder for Hands-On Activity #2
 - ▣ update initial audit from Rockville WSC data validity info
 - ▣ Check for data validity issues
 - ▣ Include data validity scoring
- Applied Activity #2
 - ▣ update your system audit with data validity grades
 - ▣ Note from audit results top 3 priority areas for further investigation needed to improve overall data validity score



Corrective Actions – Data Validity Score < 50

57

- Improve Data validity for next audit cycle
 - ▣ Install customer meters, or implement calibration policy
 - ▣ Install or calibrate source meters
 - ▣ Improve policy on water usage estimates for non-metered users



Corrective Actions – Data Validity Score > 50

58

- Flow Tests on Supply/master meters
- Signal calibration
- Scrub of production data:
 - ▣ Data gaps
 - ▣ Irregular patterns
- Scrub billing Data:
 - ▣ Duplicate volumes
 - ▣ Non-potable volumes
 - ▣ Wrong timeframes
 - ▣ Irregular patterns



Audit Results - Volumes and Values

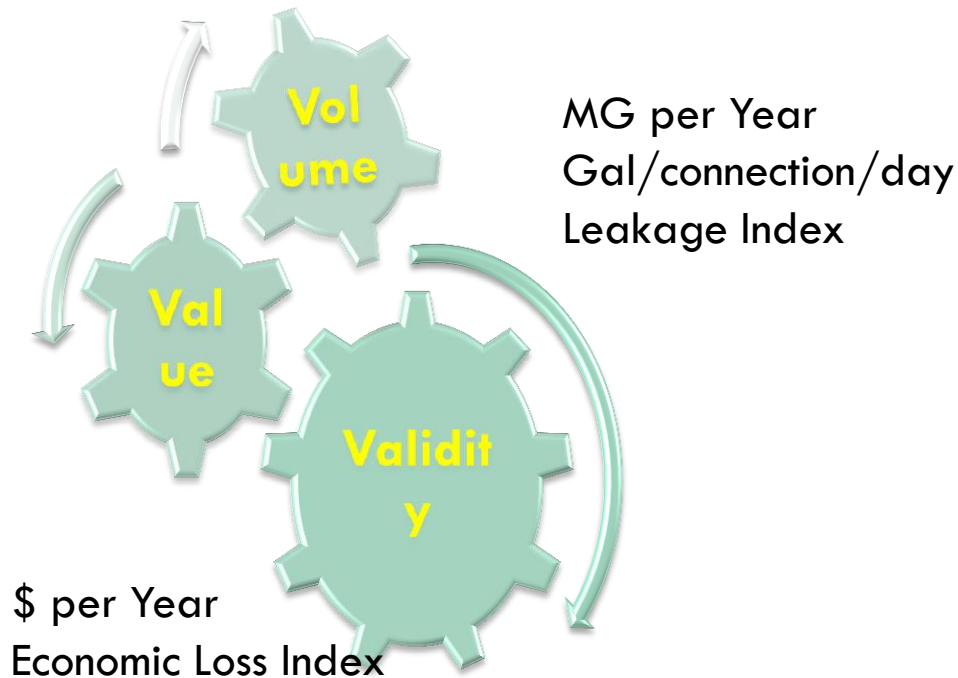
59

- Software calculates loss of water in Volume and Cost (Non-revenue water)



Volumes and Values – 3-V concept

60

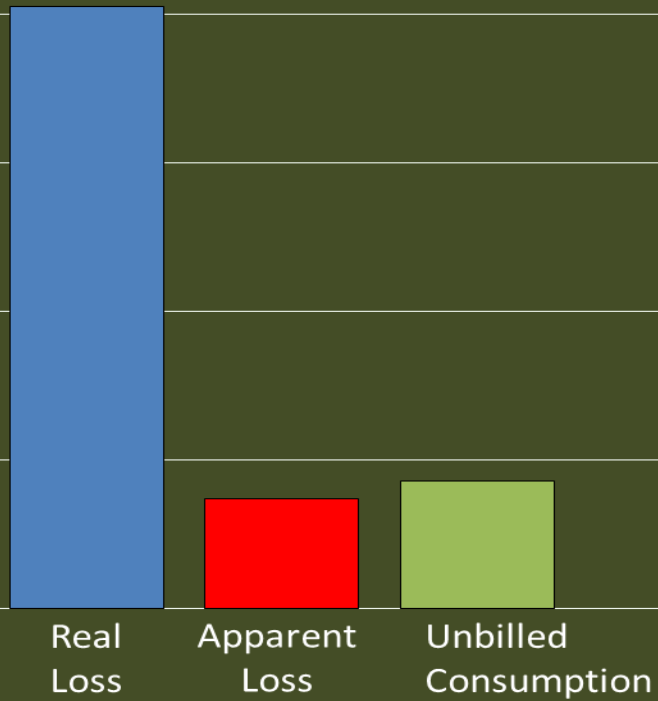


Water Audit Data Validity Score
95% Confidence Limits
Key Data Input Grades



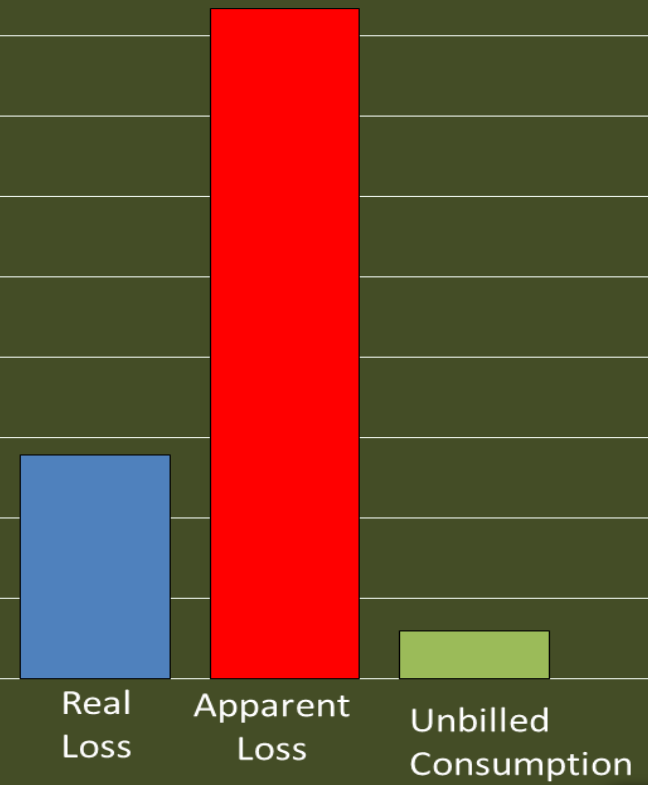
Volume

NRW Components - By Volume
(MG) - Level 2



Value

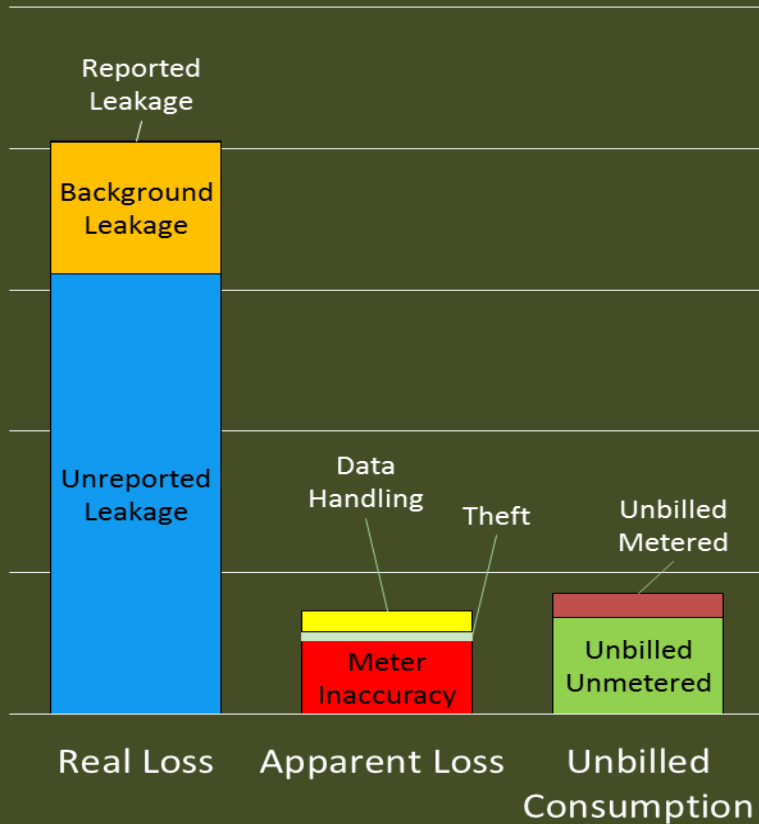
NRW Components - By Value
Level 2



Volume

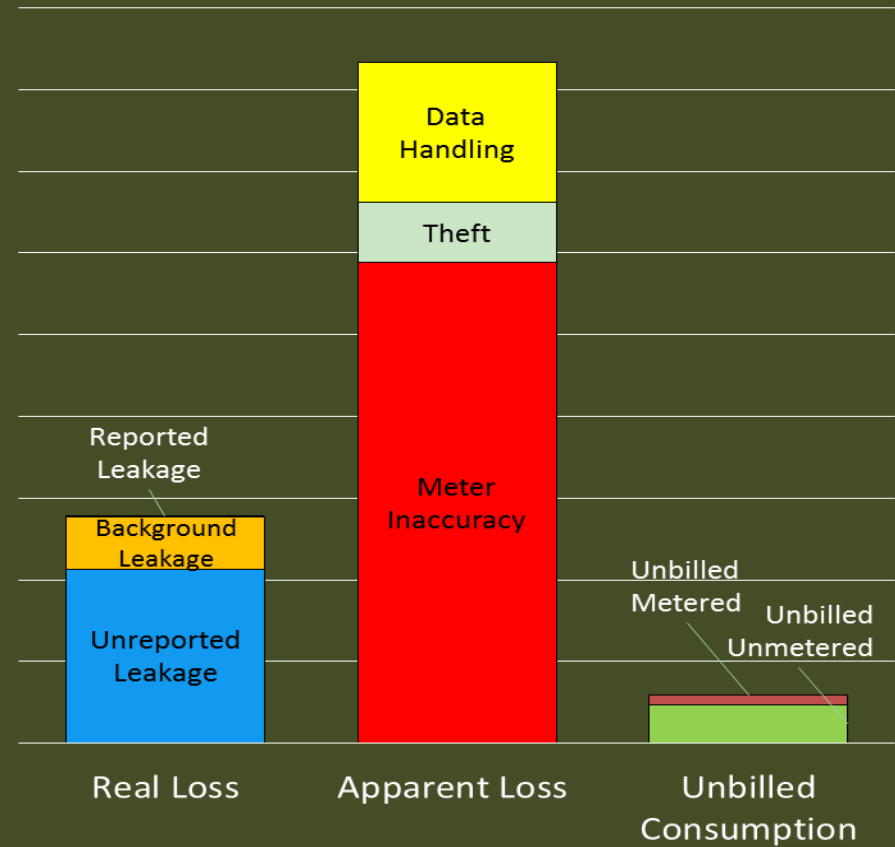
62

NRW Components - By Volume (MG)
Level 3



Value

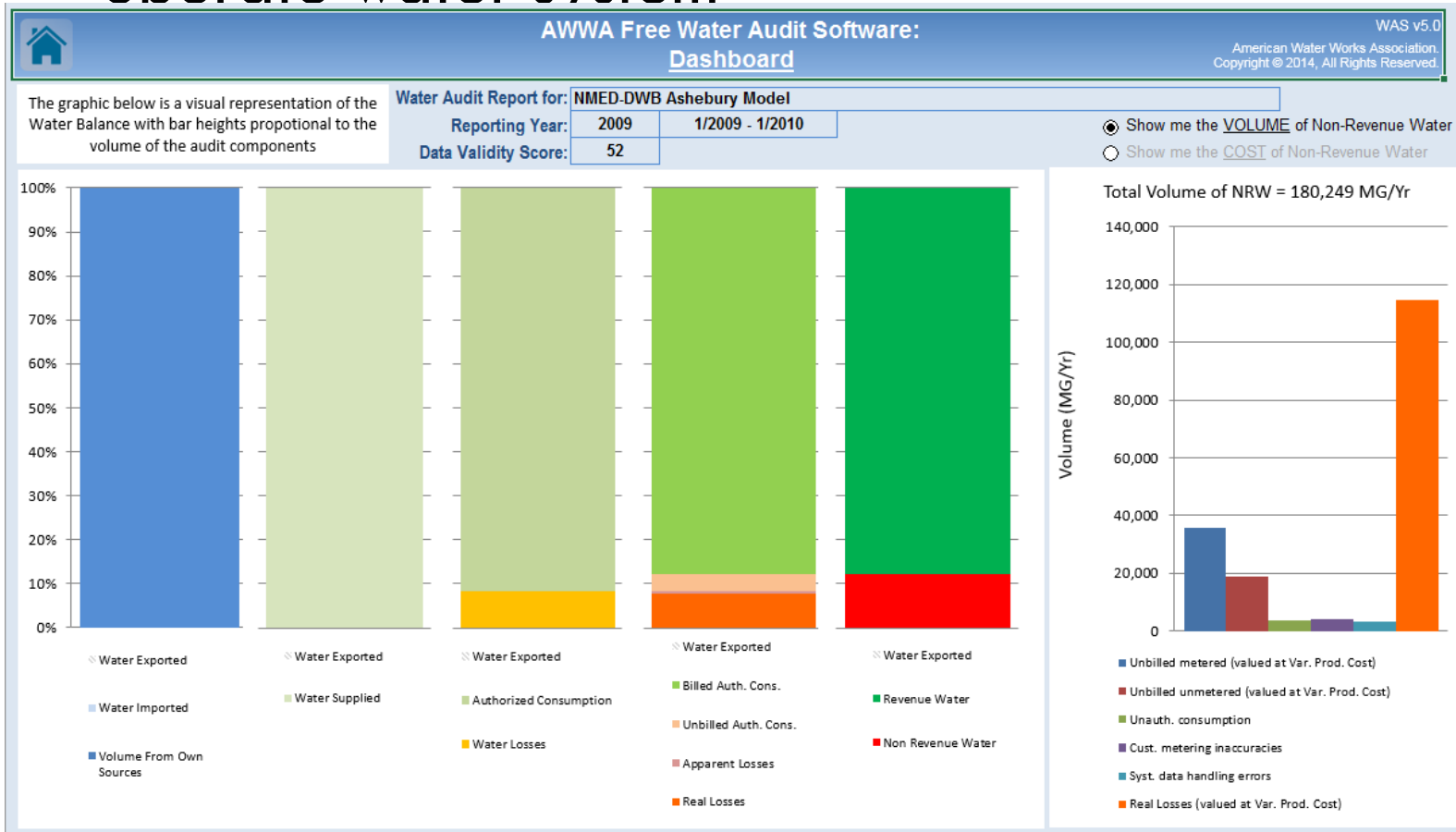
NRW Components - By Value
Level 3



Volumes and Values – Large System Volume

63

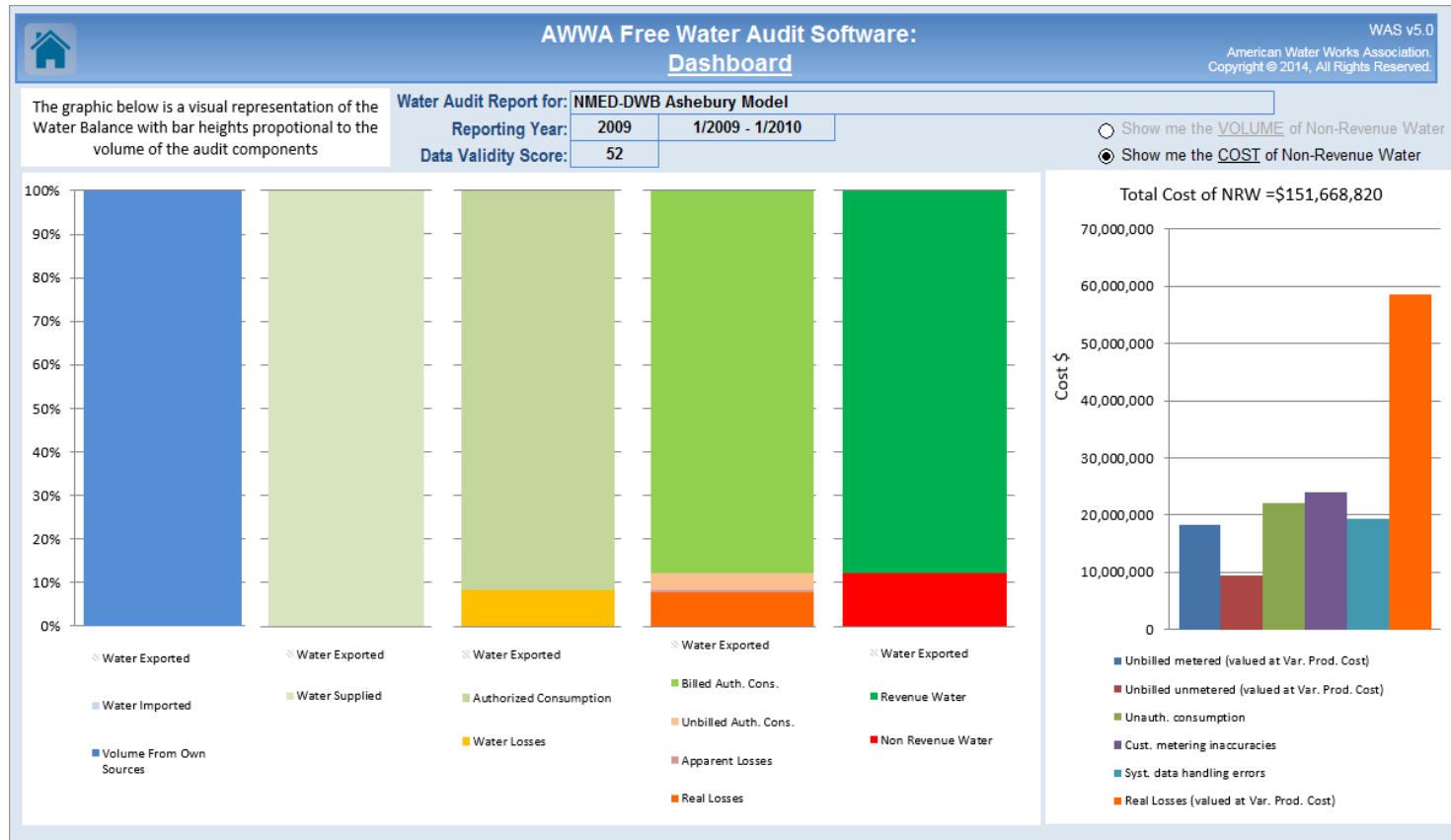
- 1.5 MG/yr supplied, \$3 million/yr total cost to operate water system



Volumes and Values – Large system Cost

64

- System info: 1.5 MG/yr supplied, \$3 million/yr total cost to operate water system



How to interpret results

65



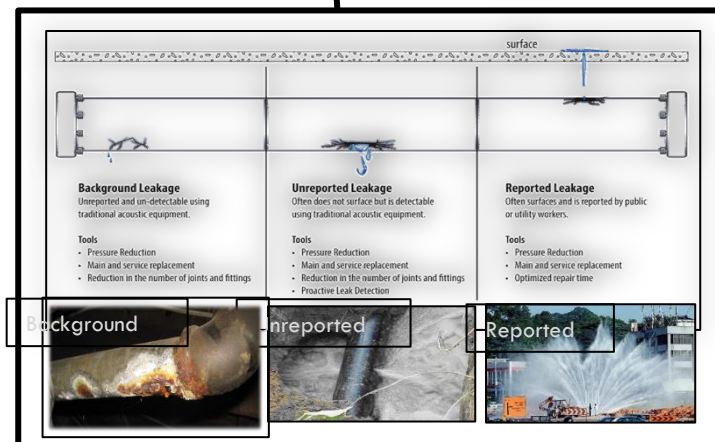
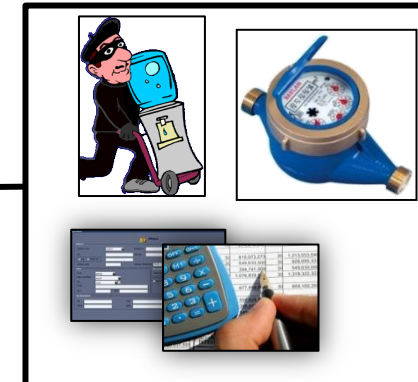
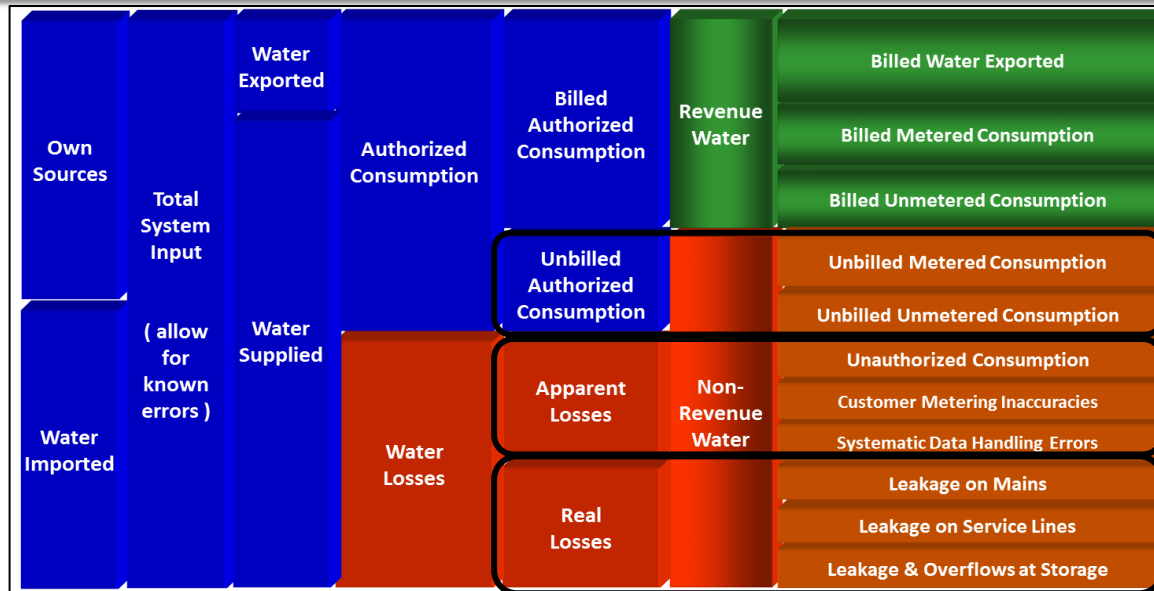
Corrective Actions – Data validity Scores > 50

66

- Improve system performance, identify if Real Loss or Apparent Losses dominate
 - Status Component Analysis for Real Loss
 - Status Component Analysis for Apparent Loss



Real Loss Component analysis



Component Analysis – Real Loss

68



LEAKAGE
ON MAINS



LEAKAGE ON
SERVICE
LINES

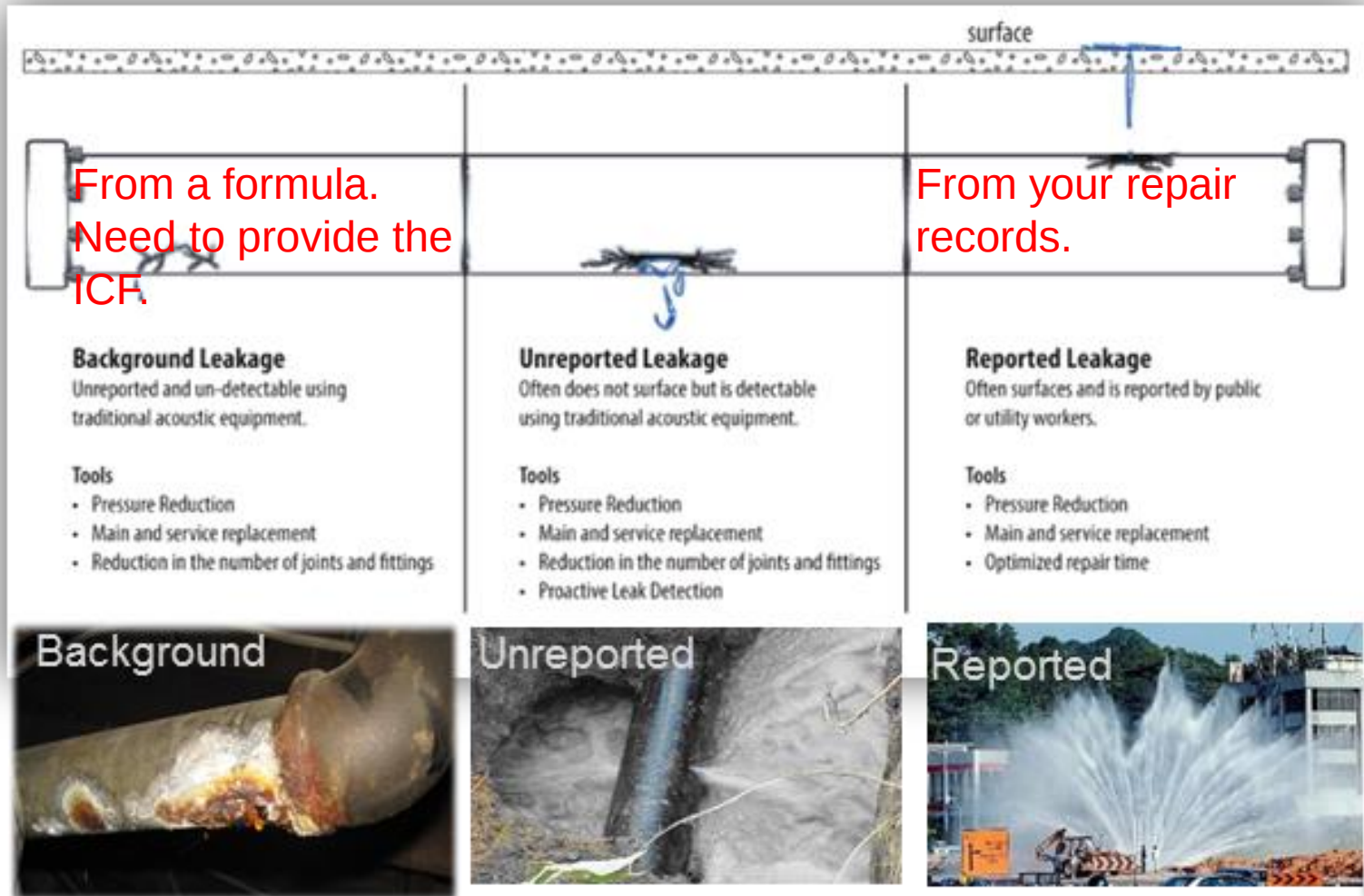


LEAKAGE OR
OVERFLOW AT
STORAGE TANKS



Real Loss Component Analysis

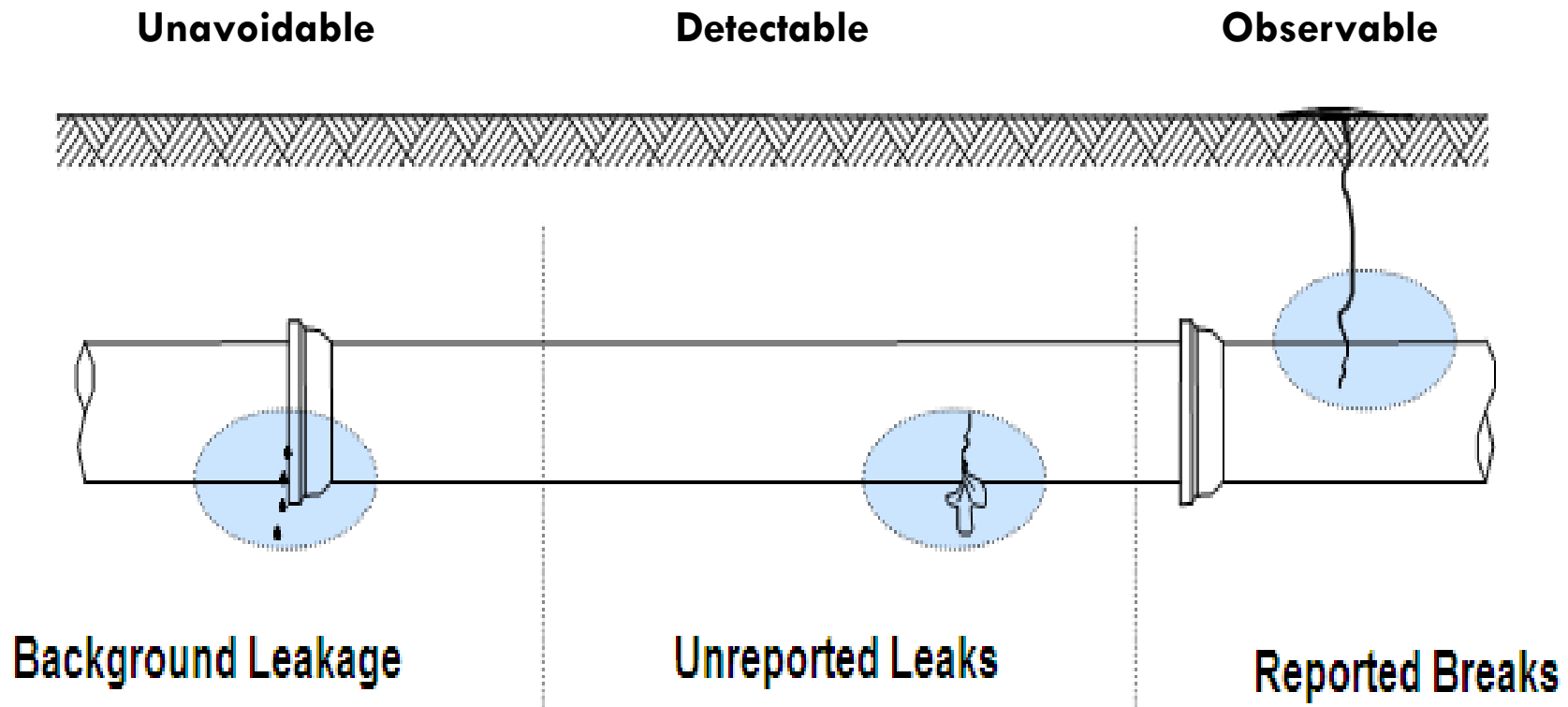
69



Component Analysis- Real Loss

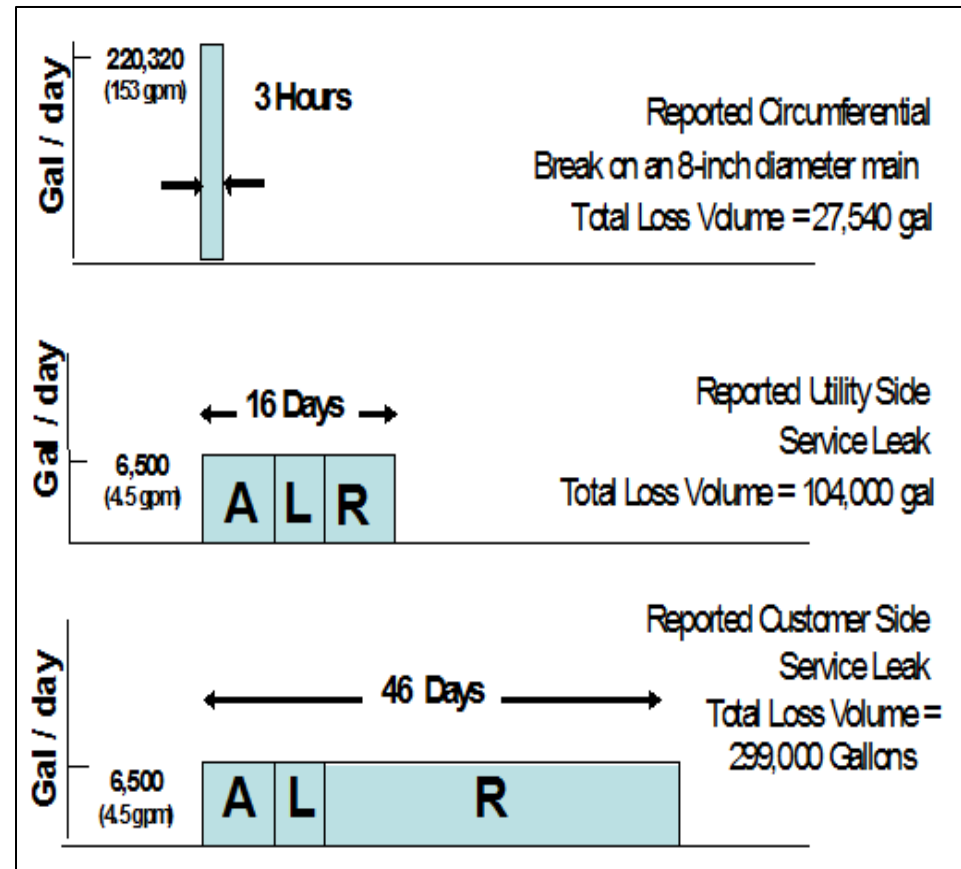
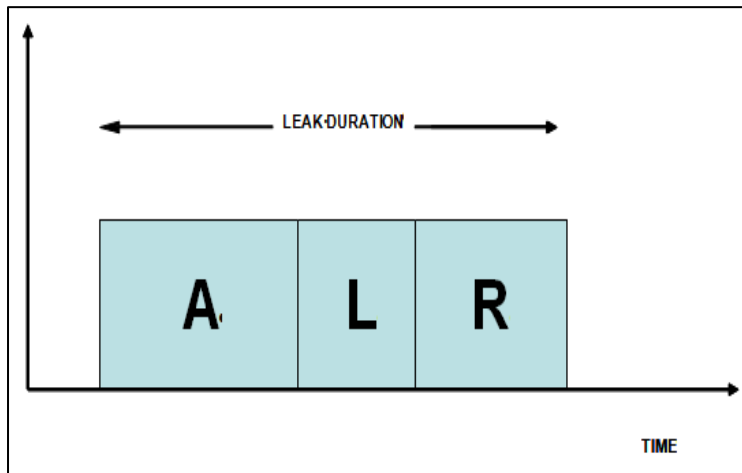
70

□ Categories of Water Loss



Real Loss Component Analysis: The Life of a Leak; Awareness, Location & Repair

71



Real Loss Component Analysis: Basic data needed

72

□ Failure Data

- ▣ Break type: reported/unreported
- ▣ Main or service
- ▣ Location
- ▣ Line size
- ▣ Day/time break discovered
- ▣ Day/time break was repaired

□ Other Data

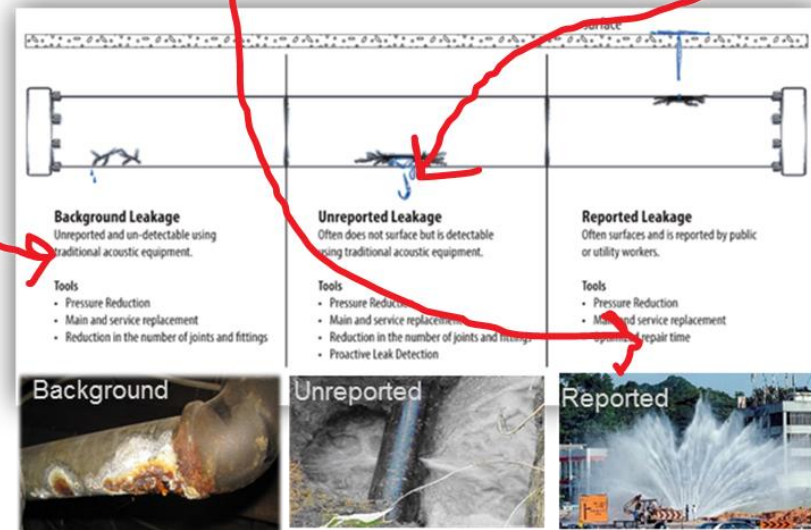
- ▣ Storage tank volume (total)
- ▣ Average age of pipe network
- ▣ Data from AWWA M36 water audit



Real Loss Component Analysis Results

73

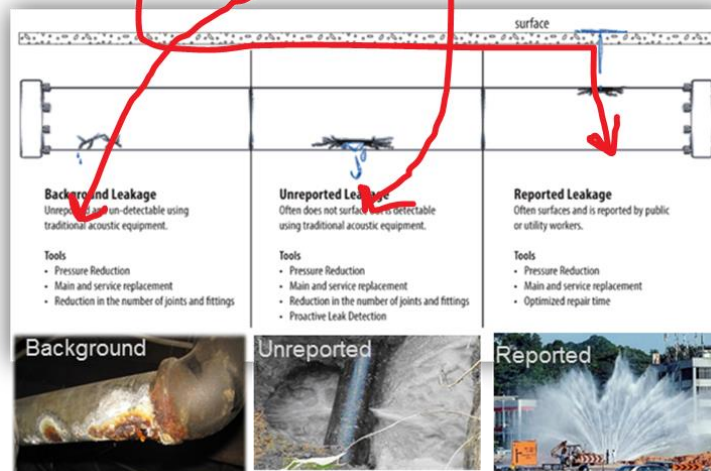
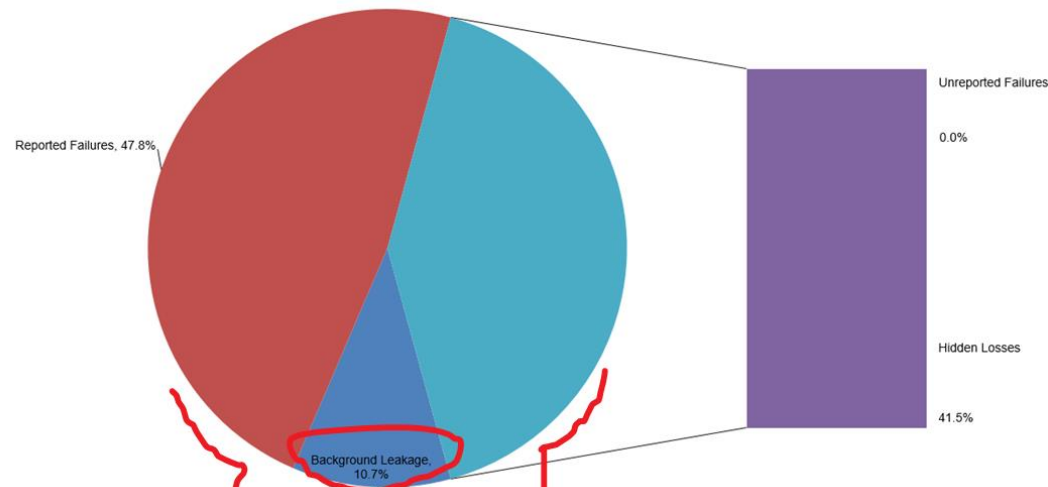
REAL LOSS COMPONENT ANALYSIS RESULTS				
System Component	Background Leakage	Reported Failures	Unreported Failures (Hidden Losses)	Total
	(MG)	(MG)	(MG)	(MG)
Reservoirs	3	-	-	3
Mains and Appurtenances	77	574	-	651
Service Connections	144	11	-	154
Total Annual Real Loss	224	584	-	808
Real Losses as Calculated by Water Audit				1,612
Hidden Losses/Unreported Leakage Currently Running Undetected				804



Real Loss Component Analysis Results

74

Real Loss Components



Component Analysis – Real Loss

75

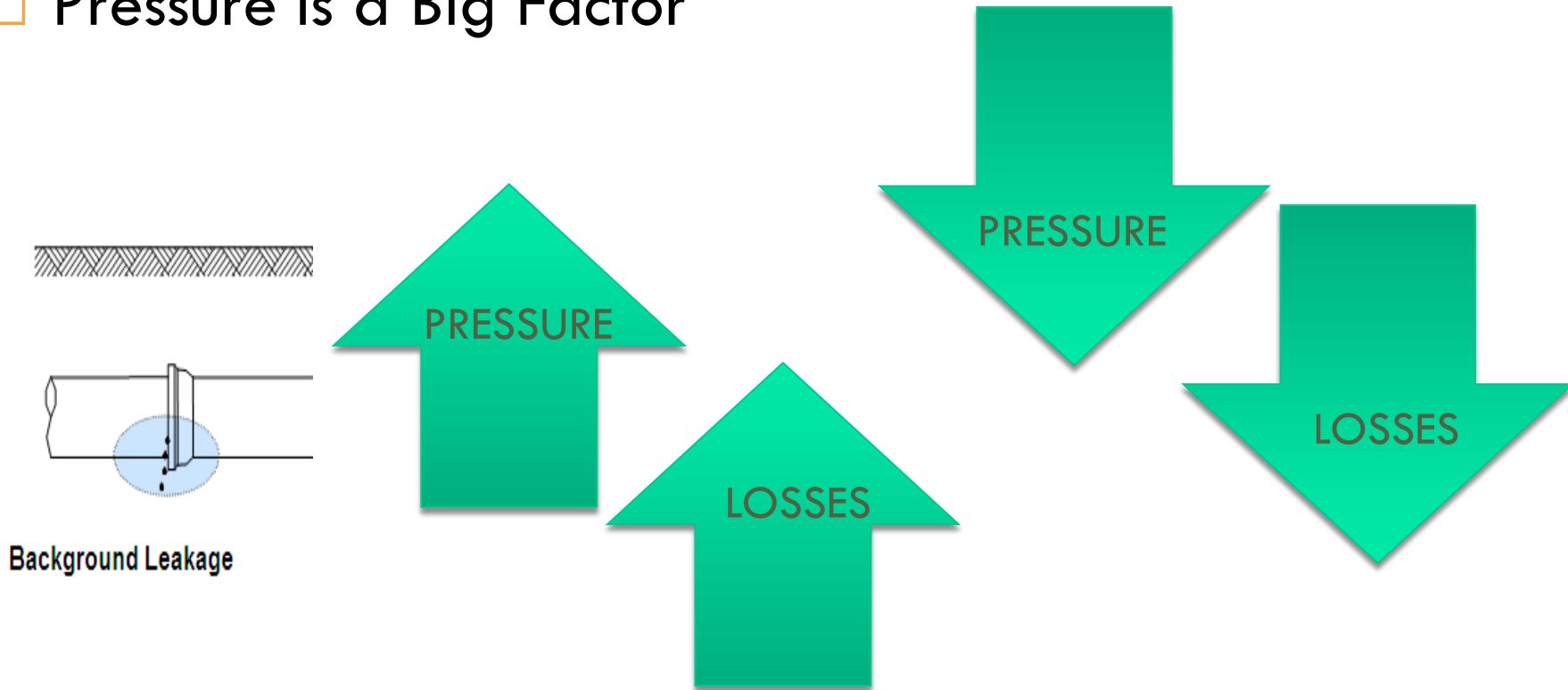
- What is my quantity of Unavoidable or Background Leakage (UARL)?
 - ▣ Calculate based on:



Component Analysis – Real Loss

76

□ Pressure is a Big Factor



Component Analysis – Real Loss

77

- Tools to address Background leakage:
 - ▣ Pressure stabilization
 - ▣ Pressure reduction
 - ▣ Main and service line replacement
 - ▣ Reduction of # of joints and fittings

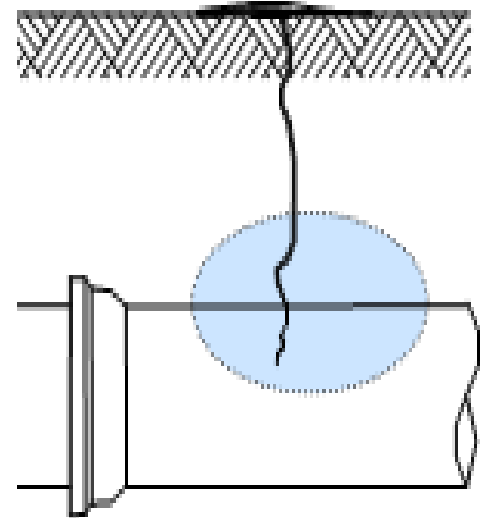


Component Analysis – Real Loss

78

□ Reported Leaks

- Condition, type, & length of pipe
- Depth
- Type of soil
- Installation
- Pressure
- Inspection of system



Reported Breaks



Component Analysis – Real Loss

79

- Tools to Address Reported Breaks
 - ▣ Pressure stabilization
 - ▣ Pressure reduction
 - ▣ Main and service replacement
 - ▣ Optimize repair and response time



Real Loss Component Analysis – Activity 3

80

- Placeholder for Hands-On Activity #3
 - Use AWWARf Leakage Component Analysis Model to update initial audit from Rockville WSC
 - Identify volume & value of the real loss sub-component of the Rockville WSC NRW
- Applied Activity #3
 - Assemble and input your system's break data into the AWWARf model
 - Otherwise, develop a plan to collect, assemble and use the required break data for your audit



Component Analysis – Apparent Losses

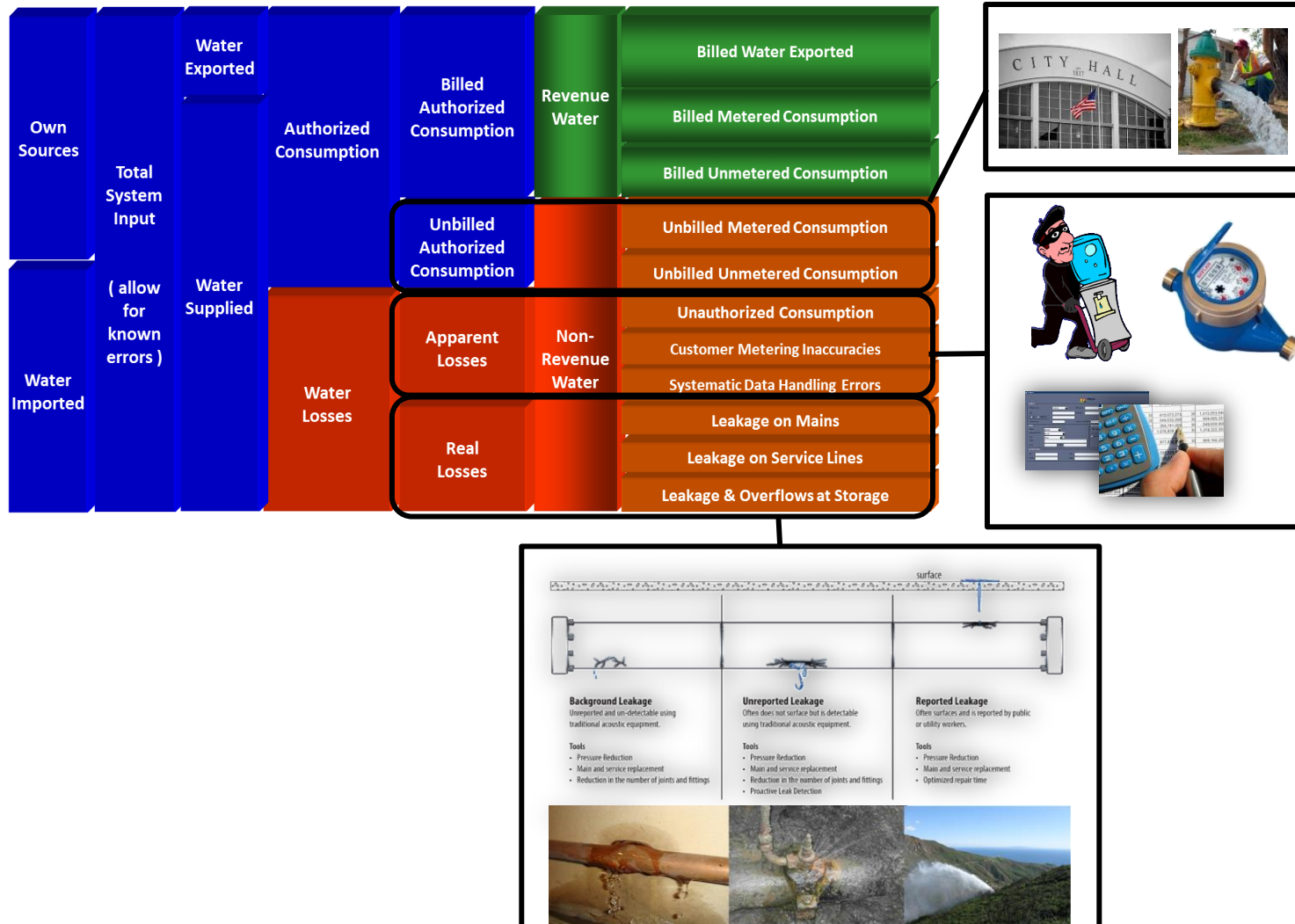
81

1. Create a water balance: separate Non-Revenue Water into Unbilled Consumption, Apparent Loss and Real Loss.
1. Test the validity: Data Validity Score & Metrics screening, data validity checking
1. Analyze the components of Unbilled Consumption, Apparent Loss and Real Loss. Use volumes & values.
1. Prioritize the components to make a plan of attack



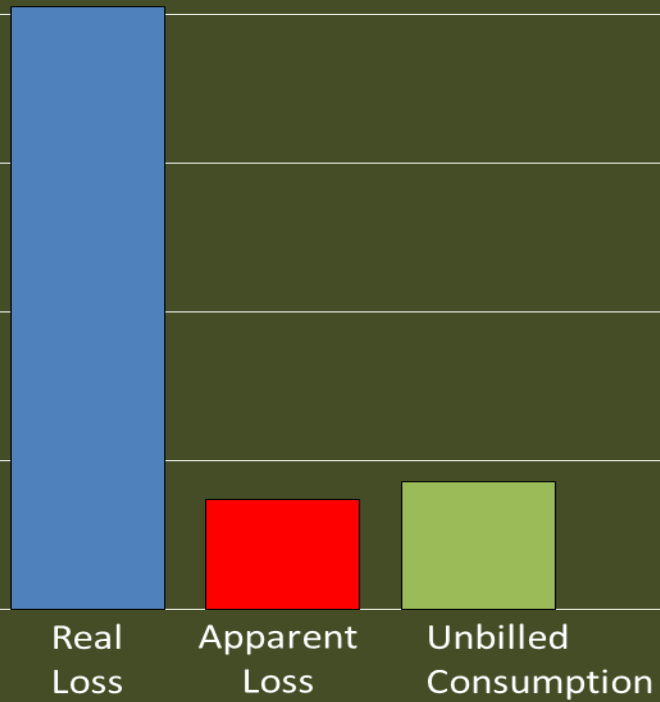
Component Analysis – Apparent Losses

82



Volume

NRW Components - By Volume
(MG) - Level 2



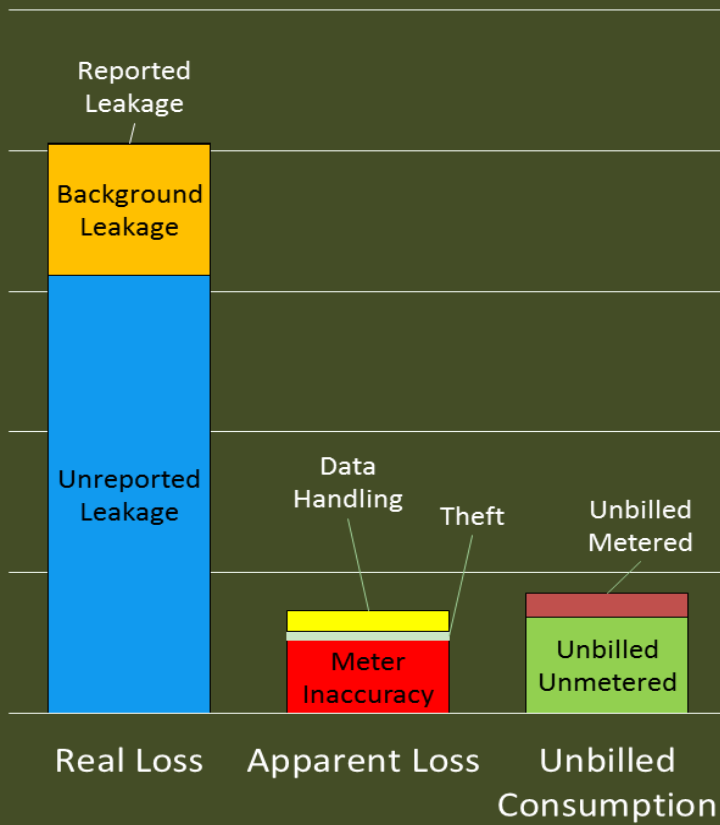
Value

NRW Components - By Value
Level 2



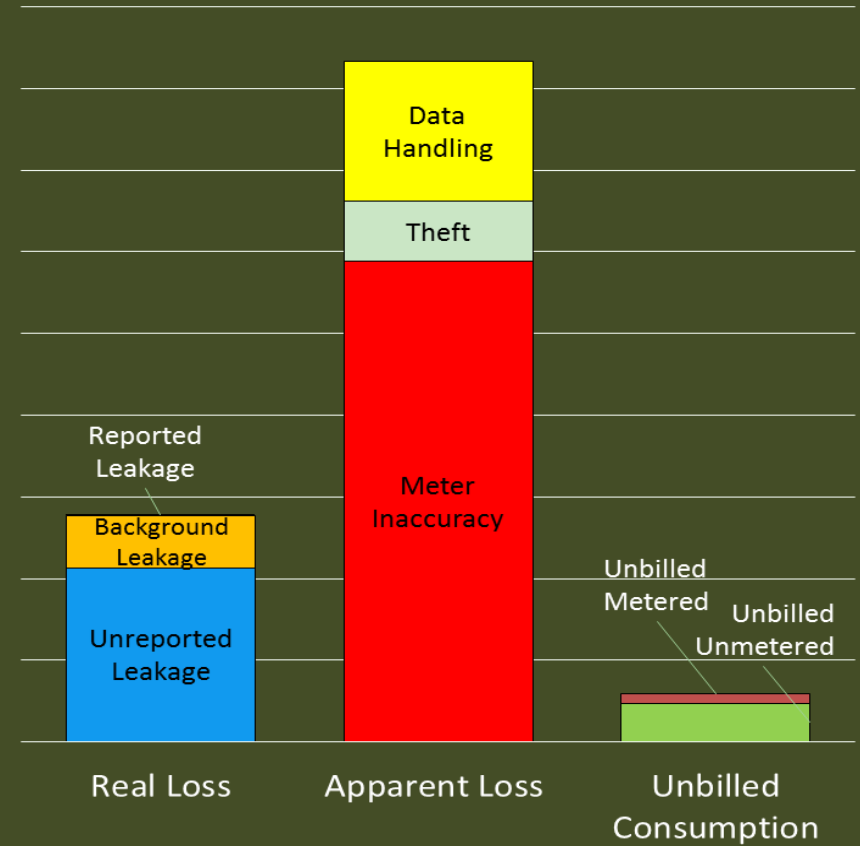
Volume

NRW Components - By Volume
(MG)
Level 3



Value

NRW Components - By Value
Level 3



Volume

Meter
Inaccuracy

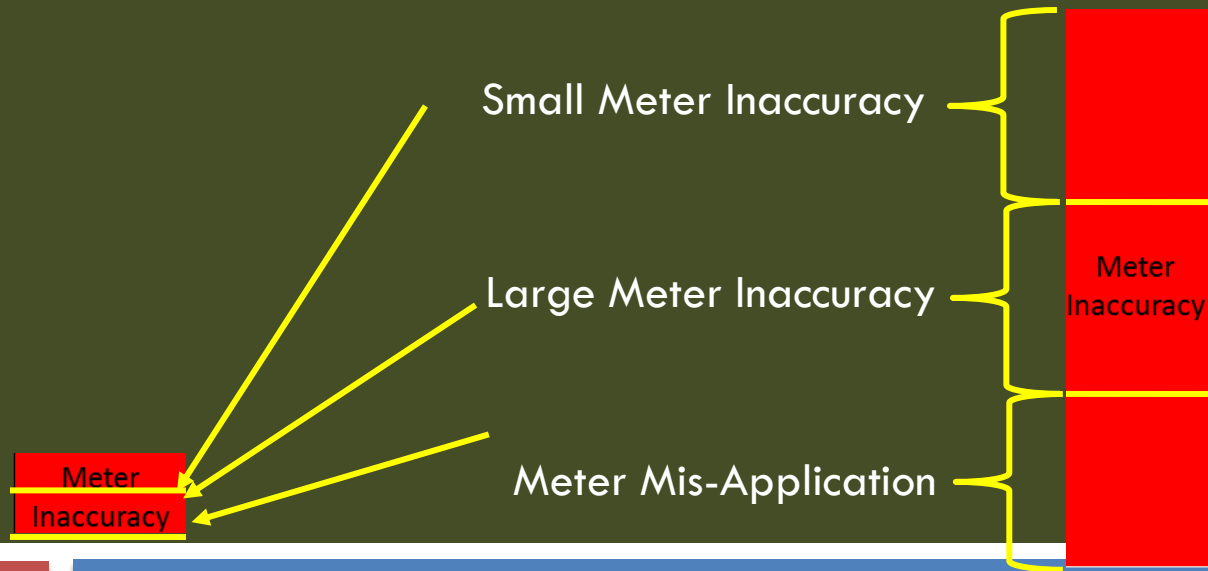
Value

Meter
Inaccuracy

M E 1

Volume
Level 4

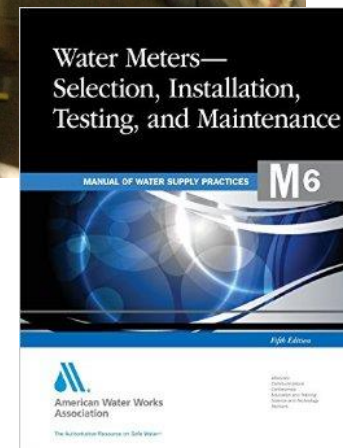
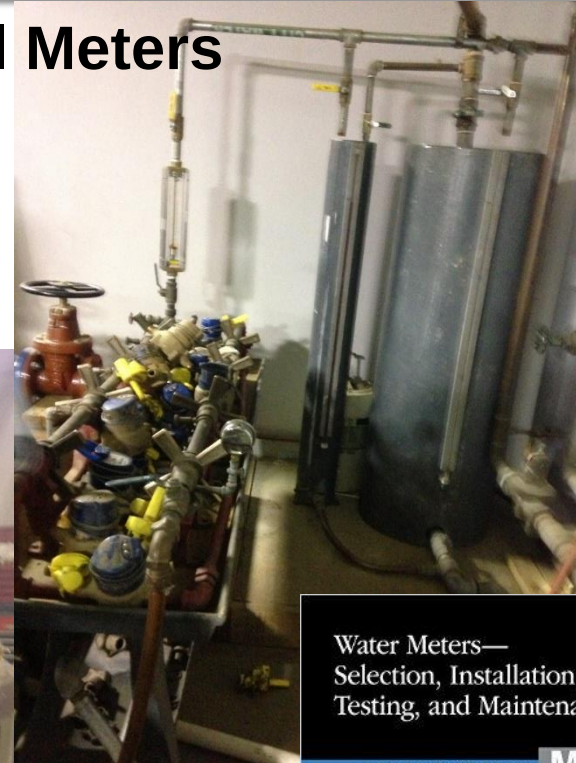
Value
Level 4



Component Analysis – Apparent Loss

87

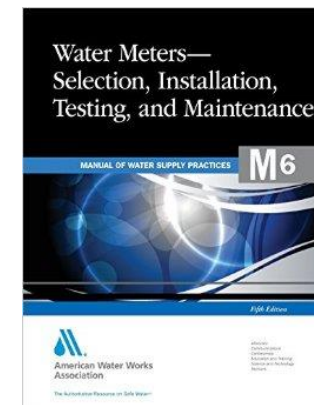
Sample Testing for Small Meters



Component Analysis – Apparent Loss

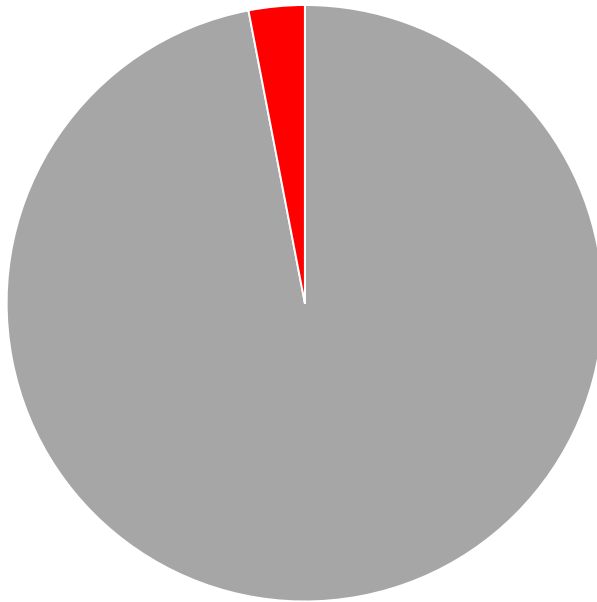
88

- Sample Testing for Small Meters
 - Select sample to test
 - Statistical significance (confidence, margin of error)
 - Consider resources for testing
 - Sample each type of meter with designed flow rate boundaries
 - Described in AWWA M6 Manual



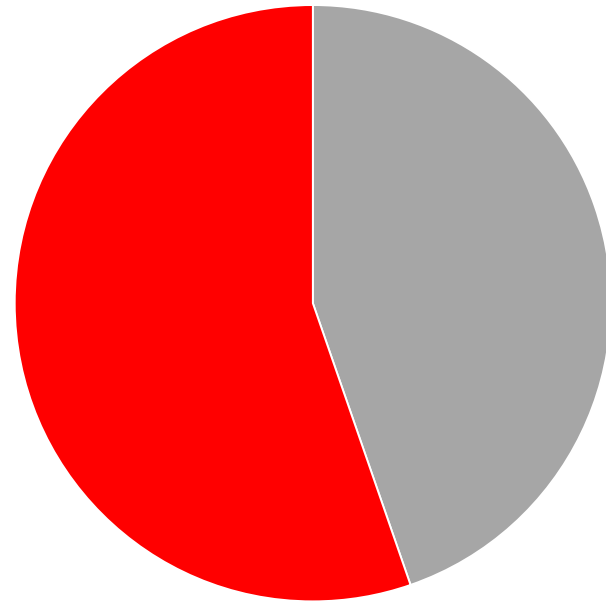
Component Analysis – Apparent Loss

Number of Meters in System



■ Small Meters ■ Large Meters

Revenue from Each Class of Meters



■ Small Meters ■ Large Meters



Component Analysis – Apparent Loss

90

- Targeted testing for Large Meters
 - Annual revenue from large meters = \$100,000
 - Estimated inaccuracy = 5 %
 - Annual large meter revenue loss = \$5,000



Component Analysis – Apparent Loss

91

- Picking which large meters to test
 - Annual revenue from specific large meter = \$10,000
 - Estimated inaccuracy = 10%
 - Annual large meter revenue being lost = \$1,000
 - Cost to test/repair meter = \$ 500
 - Is it worth it to test/repair this meter?



Component Analysis – Apparent Loss

92

- Picking which meters to test
 - Annual revenue from specific meter= \$6,000
 - Estimated inaccuracy = 5%
 - Annual large meter revenue loss = \$300
 - Cost to test/repair meter = \$ 500
- Is it working it to test/repair this meter?



Component Analysis – Apparent Loss

93

- Picking which meters to test
 - Annual revenue from specific meter= \$25,000
 - Estimated inaccuracy = 2%
 - Annual large meter revenue loss = \$500
 - Cost to test/repair meter = \$500
 - Is it worth it to test/repair this meter?



Toolbox

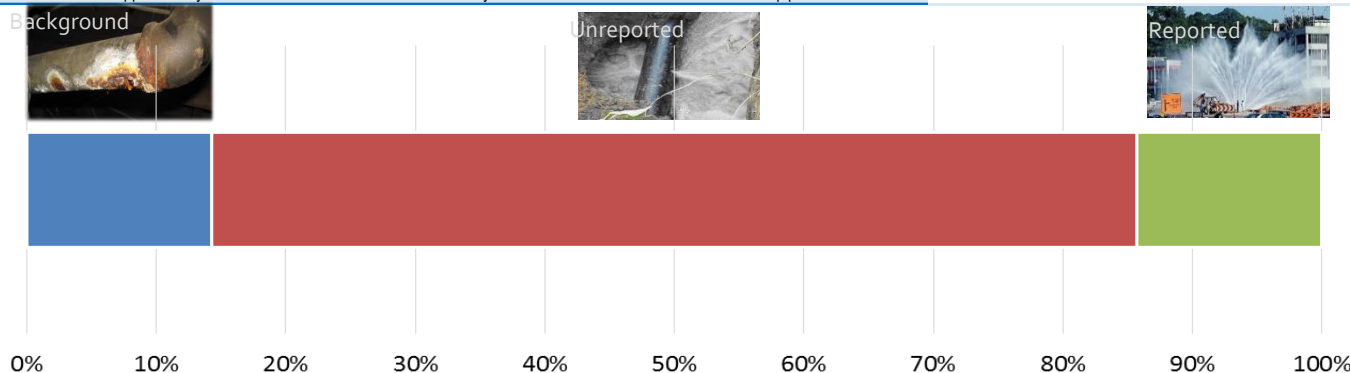
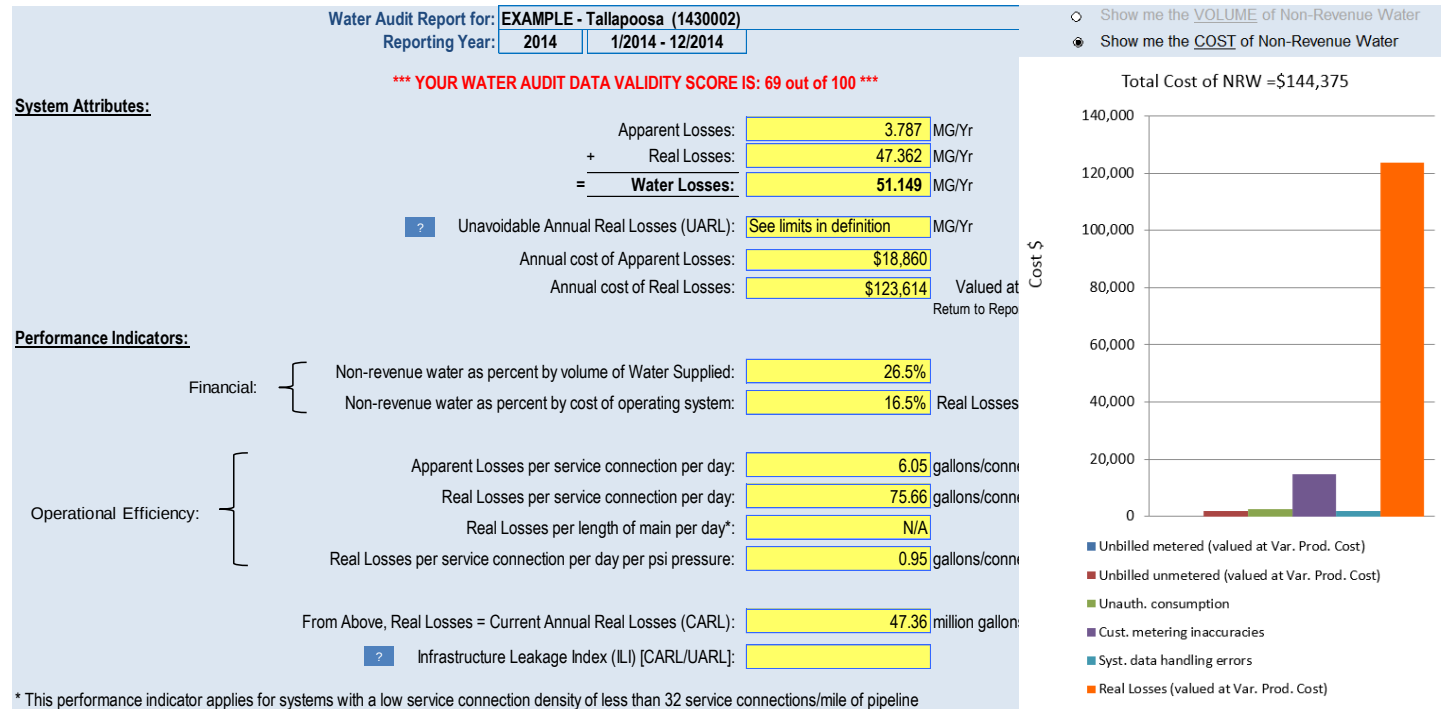
94

The Toolbox (Basic) 	Helps to Address	Level of Cost
1 - Validation of supply & consumption volumes	Low Data Validity Score, Gremlins	Low-Mid
2 - Estimating and tracking unmetered use	Validity, Unmetered Use	None-Low
3 - Installing meters on unmetered connections	Unmetered Use	Mid
4 - Billing system audit	Systematic Data Handling Errors	Low-Mid
5 - Meter testing & replacement	Customer metering inaccuracy	Mid-High
6 - Unidirectional flushing program	Unbilled unmetered	Low
7 - Acoustic leak survey	Unreported leakage	Mid
8 - Improve speed/quality of repairs	Unreported, Reported leakage	Low
9 - Locate & eliminate pressure transients (surges, hammers)	All 3 types of leakage	Low-Mid
10 - Reduce peak and overall pressure	All 3 types of leakage	Mid-High



Toolbox

95



Toolbox

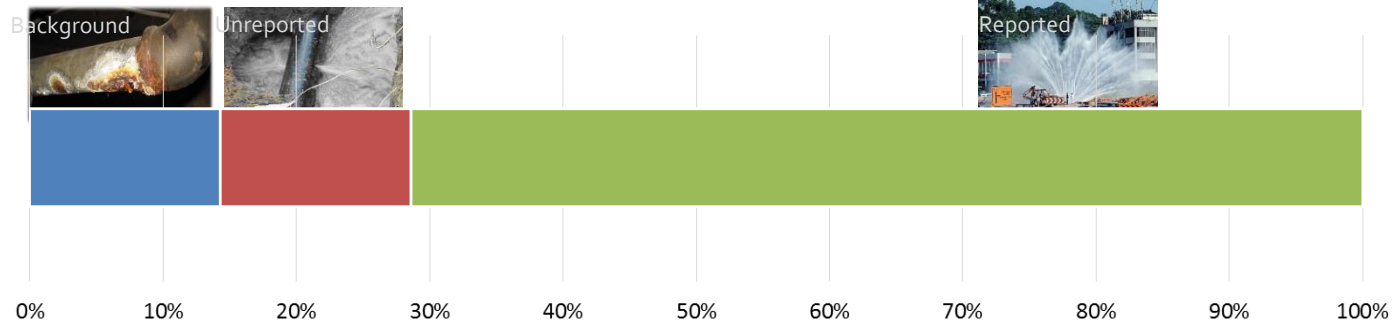
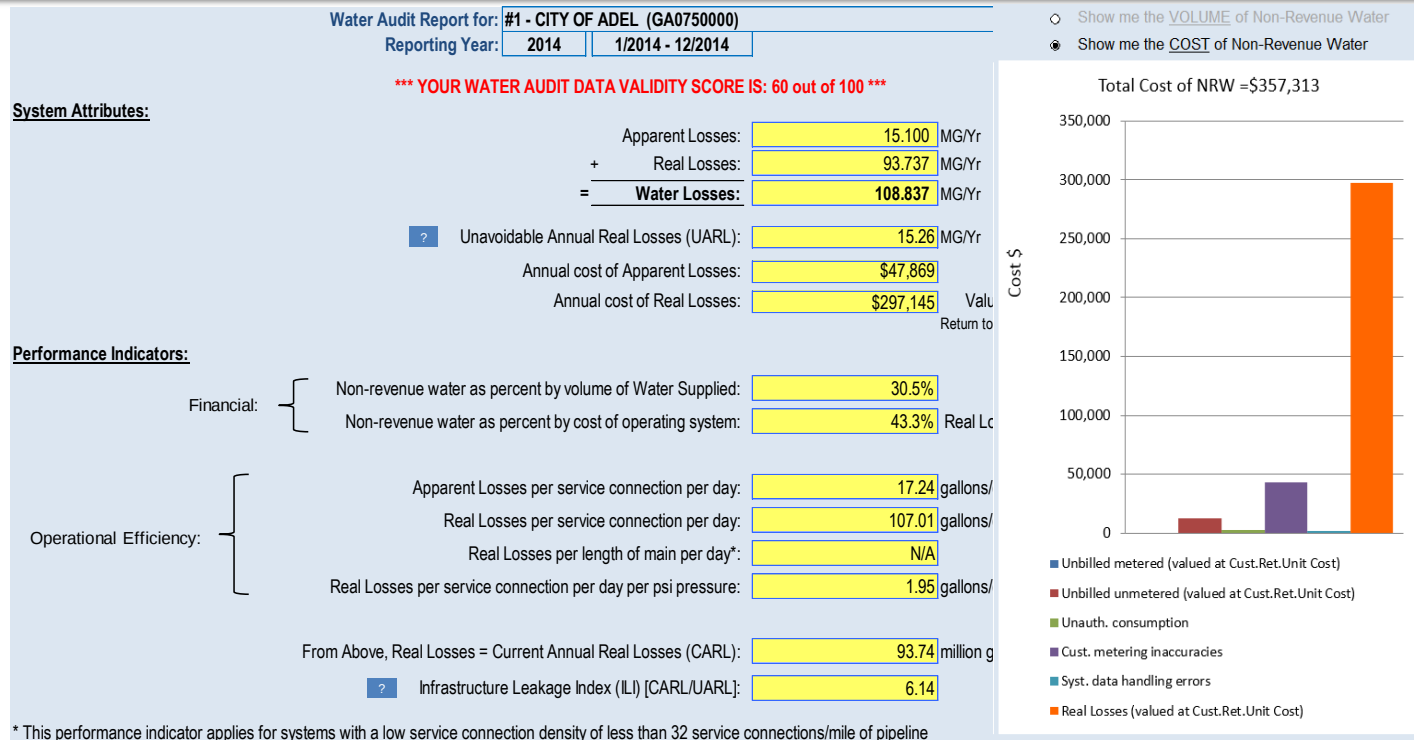
96

The Toolbox (Basic) 	Helps to Address	Level of Cost
1 - Validation of supply & consumption volumes	Low Data Validity Score, Gremlins	Low-Mid
2 - Estimating and tracking unmetered use	Validity, Unmetered Use	
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6 - Unidirectional flushing program	Unbilled unmetered	Low
7 - Acoustic leak survey	Unreported leakage	Mid
8 - Improve speed/quality of repairs	Unreported, Reported leakage	Low
9 - Locate & eliminate pressure transients (surges, hammers)	All 3 types of leakage	Low-Mid
10 - Reduce peak and overall pressure	All 3 types of leakage	Mid-High



Toolbox

97



Toolbox

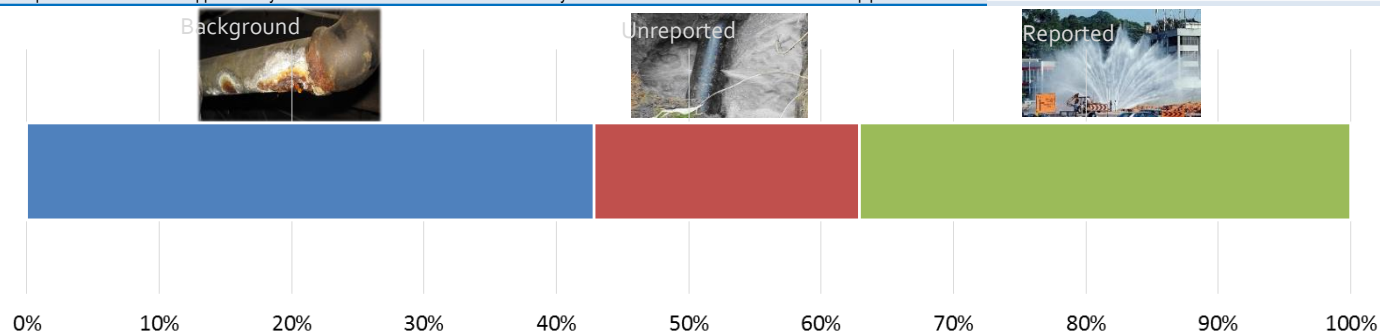
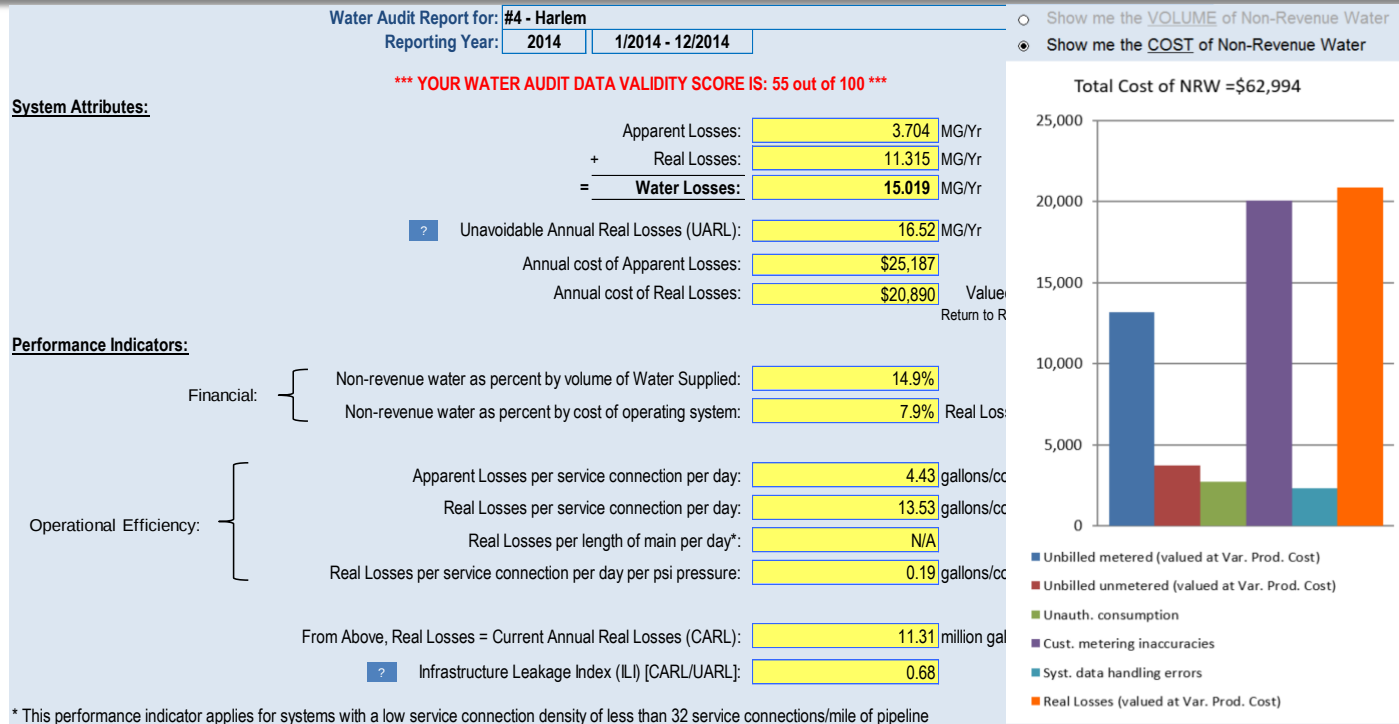
98

The Toolbox (Basic) 	Helps to Address	Level of Cost
1 - Validation of supply & consumption volumes	Low Data Validity Score, Gremlins	Low-Mid
2 - Estimating and tracking unmetered use	Validity, Unmetered Use	
3 - Installing meters on unmetered connections	Unmetered Use	Mid
4 - Billing system audit	Systematic Data Handling Errors	Low-Mid
5 - Meter testing & replacement	Customer metering inaccuracy	Mid-High
6 - Unidirectional flushing program	Unbilled unmetered	Low
7 - Acoustic leak survey	Unreported leakage	Mid
8 - Improve speed/quality of repairs	Unreported, Reported leakage	Low
9 - Locate & eliminate pressure transients (surges, hammers)	All 3 types of leakage	Low-Mid
10 - Reduce peak and overall pressure	All 3 types of leakage	Mid-High



Toolbox

99



Toolbox

100

The Toolbox (Basic) 	Helps to Address	Level of Cost
1 - Validation of supply & consumption volumes	Low Data Validity Score, Gremlins	Low-Mid
2 - Estimating and tracking unmetered use	Validity, Unmetered Use	
3 - Installing meters on unmetered connections	Unmetered Use	Mid
4 - Billing system audit	Systematic Data Handling Errors	Low-Mid
5 - Meter testing & replacement	Customer metering inaccuracy	Mid-High
6 - Unidirectional flushing program	Unbilled unmetered	Low
7 - Acoustic leak survey	Unreported leakage	Mid
8 - Improve speed/quality of repairs	Unreported, Reported leakage	Low
9 - Locate & eliminate pressure transients (surges, hammers)	All 3 types of leakage	Low-Mid
10 - Reduce peak and overall pressure	All 3 types of leakage	Mid-High



Toolbox – Data Validity

101

- If Data Validity Score is less than 50, focus on improving data validity
 - ▣ Validation of supply & consumption volumes
 - ▣ Estimating and tracking unmetered use
 - ▣ Master Meter annual testing program
 - ▣ Mapping the water system



Toolbox – Authorized, Unbilled usage

102

- If Data Validity Score is greater than 50, and If areas of focus include Authorized, Unbilled consumption:
 - Review policies & procedures for unbilled customers
 - Install meters on unmetered connections
 - Unidirectional Flushing Program
 - Customer meter testing & replacement program
 - Theft deterrence
 - Billing system audit



Toolbox: Real Losses

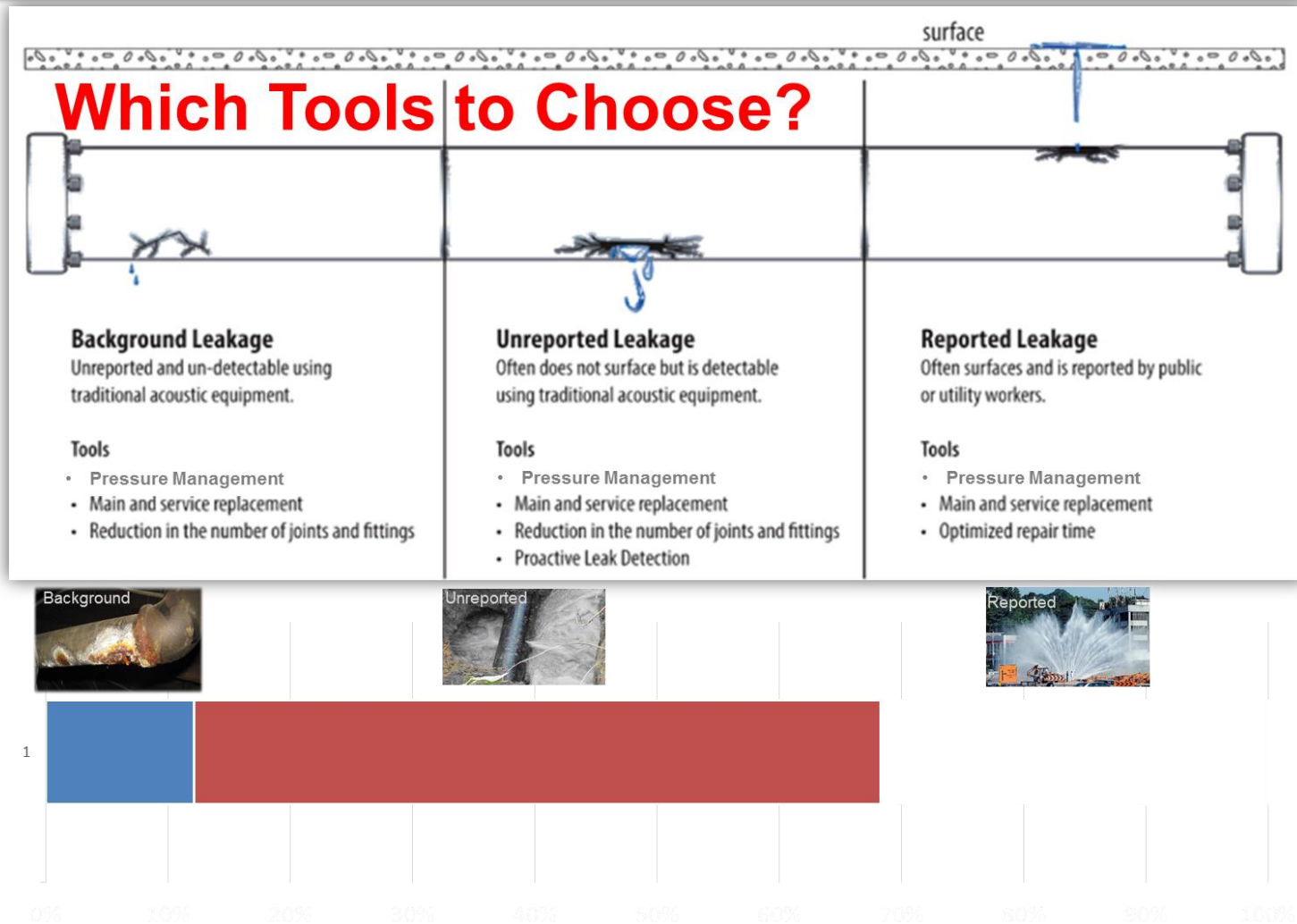
103

- If Data Validity Score is greater than 50, and if areas of focus include real losses:
 - ▣ Collecting & Analysis of break data
 - ▣ Improve speed/quality of repairs
 - ▣ Locate & eliminate pressure transients (surges, hammers, etc.)
 - ▣ Night flow analysis
 - ▣ Reduce peak & overall pressure
 - ▣ Main replacement
 - ▣ Acoustic Leak Survey



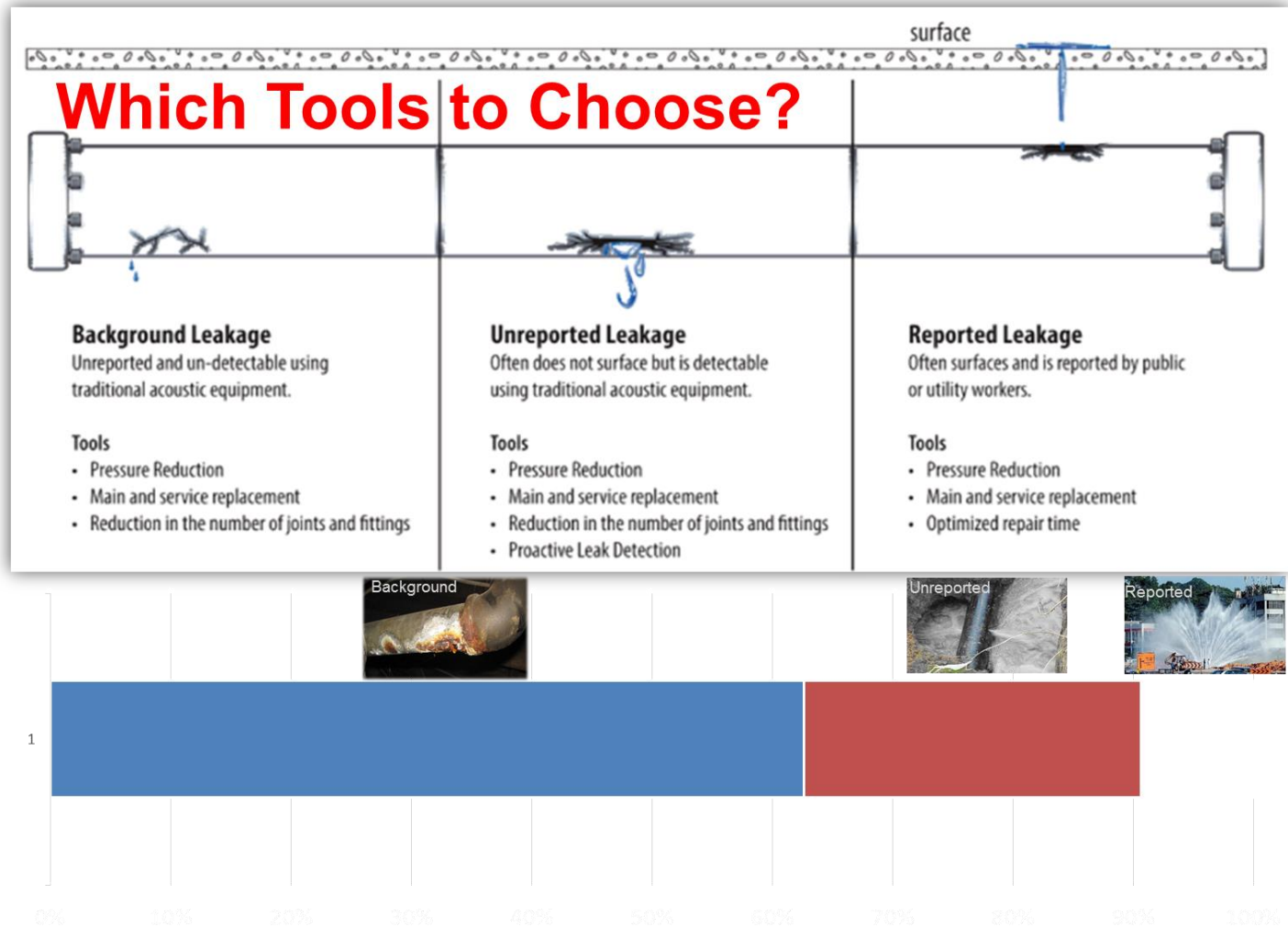
Real Loss Component Analysis Results

104



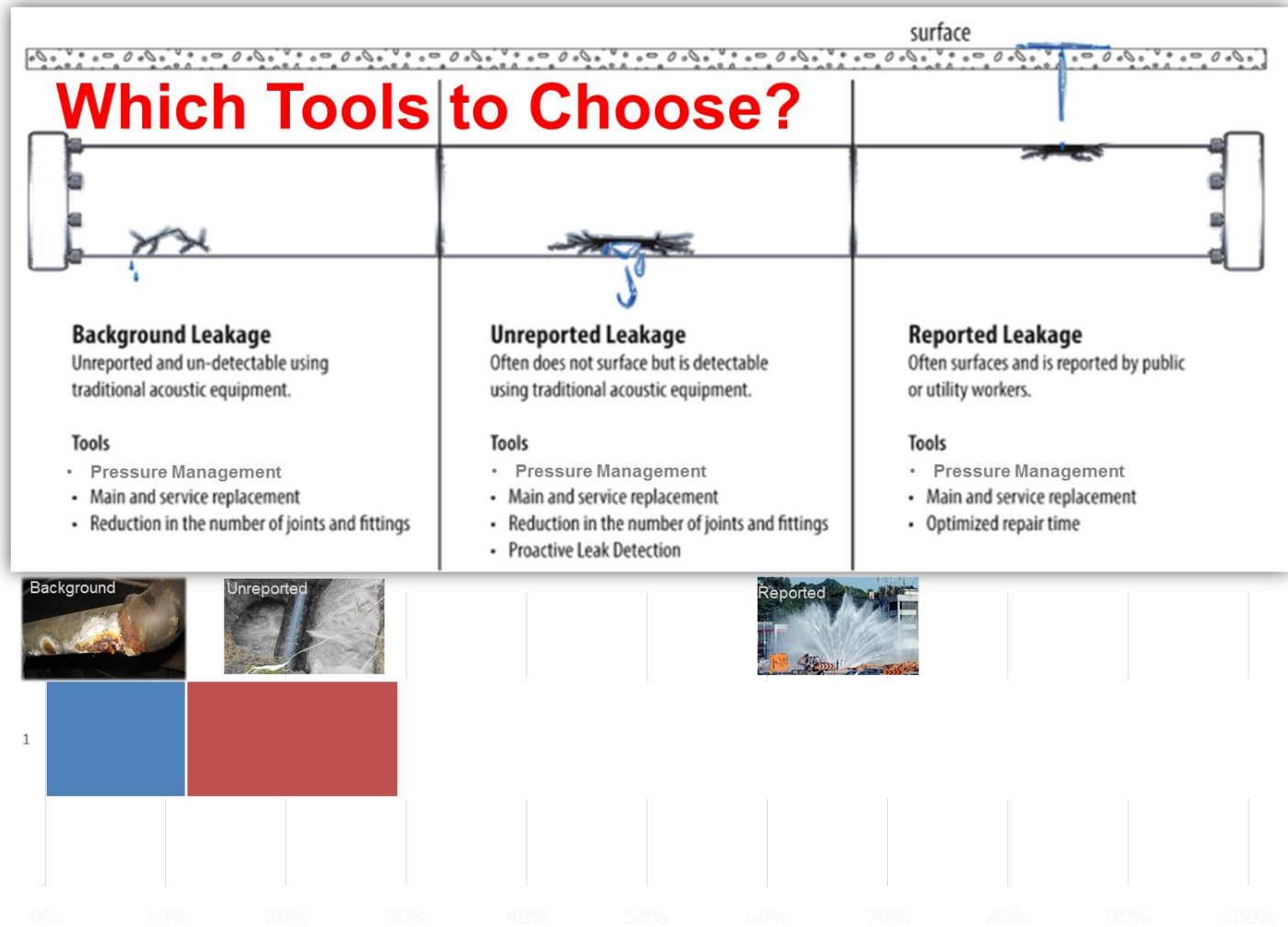
Real Loss Component Analysis Results

105



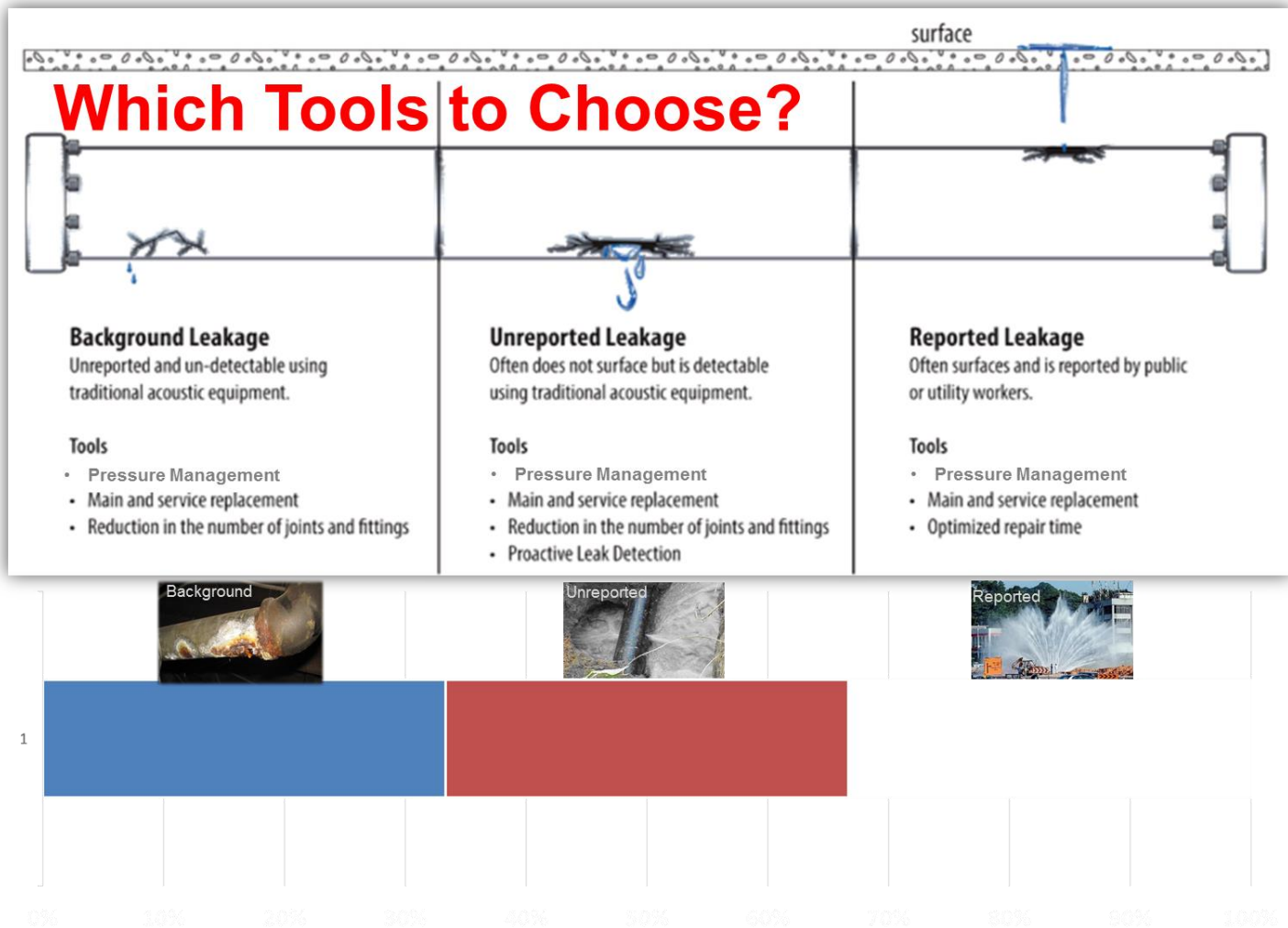
Real Loss Component Analysis Results

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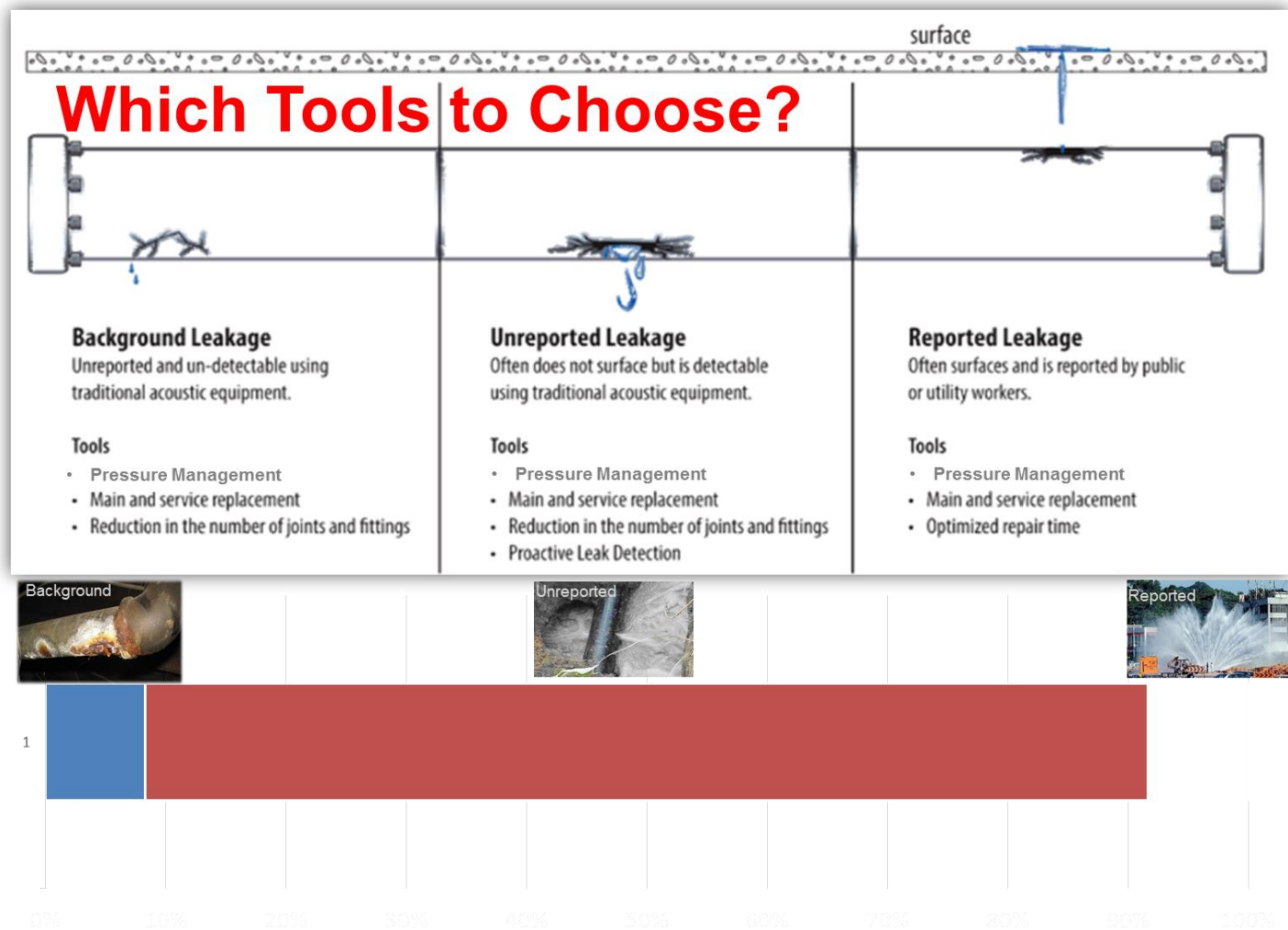
Real Loss Component Analysis Results

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Real Loss Component Analysis Results

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Summary and Toolbox Decisions – Activity 4

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- Placeholder for Hands-On Activity #4
 - ID all appropriate toolbox tools to address NRW for each system in A#4 Toolbox Decision Exercise
 - Fine-tune Rockville WSC audit for individual data validity, overall data score, performance indicators and total annual cost of NRW
 - ID all appropriate toolbox tools to address Rockville WSC NRW
- Applied Activity #4
 - Summarize your own system's audit
 - ID all appropriate toolbox tools to address your NRW



What we learned

110

- What is a Water Audit?
- What are the Benefits to annual water audits?
- What triggers voluntary & required water audits?
- How to conduct a water audit using AWWA M36 software
- How to interpret and report data validity
- How to interpret audit results – Volumes and Values
- How to interpret results from AWWA M36 software



Hands-On Activity #1

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- Go to www.awwa.org to download a copy of the free water audit software to your computer
- Open the software (enable editing, content, macros) to ensure it works – you need Excel
- Use the Rockville Water Supply Corp Background Info to enter data into the software
 - Use A#1 Software Exercise Results Excel file to check your entries for all software tabs
- Use this water balance exercise to identify your own system data needed to populate audit inputs



Hands-On Activity #2

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- Use the A#2 Data Validity Exercise to fine-tune the water balance inputs for the Rockville WSC
 - Use the A#2 Data Validity Exercise Trainer Notes for the water balance breakdown
- Input water balance data without, and then with data grades
 - Download each audit separately to see how it displays validity data without and with data grades
 - Compare your results with the A#2 Exercise Results without and with data grades



Applied Activity #2

113

- Follow the instructions presented in the A#2 Data Validity Applied Activity to assign data validity scores for each water balance component of your water system
- This will identify those components of your water balance that need more attention in order to bring your overall data validity score > 50



Hands-On Activity #3

114

- Download a copy of the free AWWARf Leakage Component Analysis Model from <http://www.waterrf.org/resources/pages/PublicWebTools-detail.aspx?ItemID=27> to your computer
- Open the software (enable editing, content, macros) to ensure it works – you need Excel
- Expand the Rockville water balance by following instructions and using data from the A#3a Real Loss and #3b Leakage Component Analysis exercises
 - This will ID the real loss sub-component of NRW



Applied Activity #3

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- Follow the instructions presented in the A#3 Real Loss and Leakage Component Applied Activity to assemble main and service line break and leakage data
- If you already have this data for your water system enter it into the AWWARf Leakage Component Analysis Model
 - Otherwise, develop a plan for your system to collect and maintain records of this data
- This will allow you to use the software to calculate the real loss sub-components of your NRW



Hands-On Activity #4

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- Use the A#4 Toolbox Decision Exercise to evaluate each of the systems audit results for overall validity score, performance indicators and total annual cost of NRW
- On each systems evaluation form record your observations of the metrics, the top three focus areas and from the ten toolbox tools the best tool(s) to address each focus area
- Check your conclusions using the A#4 Toolbox Decision Exercise Trainer Notes



Applied Activity #4

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- Follow the instructions presented in the A#4 Summary and Toolbox Decision Applied Activity to work through an entire audit for your system
- You may already have previous steps of the audit completed; use this activity to review the data you used for those steps
- Develop a plan to continue to improve system data for the audit and create a schedule to conduct the audit annually



Questions?

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□ Thank you

