Functional Focus Area

Audit Data Collection

Short-term loss control

Long-term loss control

Target-setting

Benchmarking

Identify Best Practices/ Best in class - the ILI is very reliable as a real loss performance indicator for best in class service

For validity scores of 50 or below, the shaded blocks should not be focus areas until better data validity is achieved.

Preliminary Comparisons - can begin to rely upon the Infrastructure Leakage Index (ILI) for performance comparisons for real losses (see below table)

Performance Benchmarking - ILI is meaningful in comparing real loss standing

Continue incremental improvements in short-term and long-term loss control interventions

Establish long-term apparent and real loss reduction goals (+10 year horizon)

Establish mid-range (5 year horizon) apparent and real loss reduction goals

Evaluate and refine loss control goals on a yearly basis

Begin to assess long-term needs requiring large expenditure: customer meter replacement, water main replacement program, new customer billing system or Automatic Meter Reading (AMR) system.

Begin to assemble economic business case for long-term needs based upon improved data becoming available through the water audit process.

Conduct detailed planning, budgeting and launch of comprehensive improvements for metering, billing or infrastructure management

Annual water audit is a reliable gauge of year-to-year water efficiency standing

Research information on leak detection programs. Begin flowcharting analysis of customer billing system

Conduct loss assessment investigations on a sample portion of the system: customer meter testing, leak survey, unauthorized consumption, etc.

Establish ongoing mechanisms for customer meter accuracy testing, active leakage control and infrastructure monitoring

Refine, enhance or expand ongoing programs based upon economic justification

Stay abreast of improvements in metering, meter reading, billing, leakage management and infrastructure rehabilitation

Launch auditing and loss control team; address production metering deficiencies

Analyze business process for customer metering and billing functions and water supply operations. Identify data gaps.

Establish/ revise policies and procedures for data collection

Refine data collection practices and establish as routine business process

Quiz

According to the AWWA M36 Water Audit Method, an acceptable level of Unaccounted For Water is:

A. 15%
B. 5%
C. 0%
D. 10%
1957 AWWA report: Revenue Producing vs. Unaccounted-for water – Defined as 'unnecessary water'.

Guidance publications on water audits, loss detection.
Water Audits & Loss Control

**THIS DECADE**

2010: WLCC publishes version 4 of the Free Water Audit Software

2014: Real Loss Component Analysis: A Tool for Economic Water Loss Control

2015: Pipe Location and Leakage Management for Small Water Systems

2016: Establishing Water Utility Guidance

**AWWA Free Water Audit Software**

- Version 5 of the Free Water Audit Software
- Downloads

**AWWA Water Loss Control - Quarterly Website Views**

**AWWA Free Water Audit Software v5.0 Downloads**

- Downloads distribution map

**Contact Information**

Mark Ginty

**Report Data**

- Water Supplied
- Non-Revenue Water
- Water Losses
- Administrative System Data
- Operational Data
- Authorized Cost Data
- Indicators
- Efficiency Indicators
- Financial Water

- Telephone: Ext.
- Email
- Start Date: 1/1/2011, 1/1/2012, 1/1/2012, 10/1/2011, 1/1/2012
- Country: United States
- Name of City or Utility: United States
- Name of Contact Person: Mark Ginty
- End Date: 12/1/2011, 12/1/2012, 12/1/2012, 9/30/2012, 12/1/2012

**Water Losses (Water Supplied - Authorized Consumption)**

- 2011: 6,022.2, 1,949.3, 1,644.4, 4,069.0, 12,050.6
- 2012: 3,000, 3,000, 4,000, 5,000, 6,000

**Infrastructure Leakage Index (ILI) [Real Losses/UARL]**

- 2011: 2.157, 1.132, 2.577, 2.051, 4.877

**Contact Information**

**Customer Retail Unit Cost (applied to Apparent Losses)**

- $3.34, $3.29, $3.90, $4.40, $4.18

**Click here to upload audit sheets**

**System Data Handling Errors**

- 2011: 955.5, 5.9, 29.7, 10.0, 0.0

**Total Annual Cost of Operating Water System**

- $93,112,000, $33,794,395, $37,993,964, $214,428,089, $130,907,514

**Unbilled Unmet Eered (1 = Default; 2 = Value)**

- 2011: 2, 2, 2, 2, 2

**Unavoidable Annual Real Losses (UARL)**

- 2011: 2,164.4, 1,093.6, 515.9, 1,462.6, 2,293.8

**Non-revenue Water as Percentage by Volume**

- 2011: 19.0%, 8.1%, 14.4%, 9.3%, 34.8%

**Real Losses per Service Connection per Day**

- 2011: 51.8, 16.5, 50.2, 38.6, 134.6

**Average Operating Pressure**

- 2011: 93.562, 817.31, 12.2, 777.1

**Volume from Own Sources**

- 2011: 44,397.0, 32,930.6, 13,769.7, 47,137.8, 37,998.3

**Volume Exported**

- 2011: 7,811.0, 95.1, -3,160.9

**Volume Imported**

- 2011: -71,845

**MAster Meter Error Adjustment**

- 2011: 248.5, 3.28, 137.7, 961.9, 988.2

**Annual Cost of Real Losses**


**Annual Cost of Apparent Losses**

- 2011: $4,523,839, $2,338,561, $1,228,525, $4,707,283, $3,616,811

**Customer Retail Unit Cost (Units)**

- $/1000 gallons (US)
- $/1000 gallons (US)
- $/1000 gallons (US)
- $/1000 gallons (US)
- $/1000 gallons (US)

**Connection Density**

- 2011: 78.7, 63.4, 59.8, 58.0, 56.5

**Average Length of Customer Service Line**

- 2011: 2,700, 200, 200, 200, 200

**Total Annual Cost of Real Losses**


**Annual Cost of Apparent Losses**

- 2011: $4,523,839, $2,338,561, $1,228,525, $4,707,283, $3,616,811

**Customer Retail Unit Cost (Units)**

- $/1000 gallons (US)
- $/1000 gallons (US)
- $/1000 gallons (US)
- $/1000 gallons (US)
- $/1000 gallons (US)
Percent who ranked topic HIGH IMPORTANCE (4 or 5) | % ranked high response

<table>
<thead>
<tr>
<th>Topic</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimal Pressure Management</td>
<td>57.7%</td>
</tr>
<tr>
<td>Reporting using Best Indicators</td>
<td>56.3%</td>
</tr>
<tr>
<td>ALC Based on Financial Analysis</td>
<td>55.9%</td>
</tr>
<tr>
<td>ValI of NRW Information</td>
<td>55.5%</td>
</tr>
<tr>
<td>Effectiveness of NRW Team &amp; Flowing</td>
<td>55.2%</td>
</tr>
<tr>
<td>Effectiveness of Leak Detection</td>
<td>55.1%</td>
</tr>
<tr>
<td>Measurement of Apparent Losses</td>
<td>54.8%</td>
</tr>
<tr>
<td>Water Balance All Components</td>
<td>54.8%</td>
</tr>
<tr>
<td>Wastewater and Stormwater</td>
<td>54.8%</td>
</tr>
<tr>
<td>Large Water Program Based on Financial Analysis</td>
<td>54.7%</td>
</tr>
<tr>
<td>ALC Based on Optimization and Rate of Rise</td>
<td>54.6%</td>
</tr>
<tr>
<td>Small Meter Program Based on Analysis and Optimization</td>
<td>27.8%</td>
</tr>
</tbody>
</table>
Today's Workshop

Warmup
Foundations - Top Down M36 Water Audit
Foundations - Developing the Inputs
Exercise - Top Down M36 Water Audit

Foundations – Data Validation
Exercise - Data Validation

Next Steps for Audit to Action

Basic Concepts
1. Utilize the Water Balance.
2. Separate Total Water Loss into Real and Apparent Loss.
3. Separate Real and Apparent Loss into their subcomponents.
4. Use metrics in units of Volume, Value & Validity to make your game plan.

AWWA Free Water Audit Software

- Industry Standard (M36)
- Free
- Defaults provided
- ~10 Volume Inputs
- ~7 System Data Inputs

awwa.org/waterlosscontrol
IWA/AWWA Standard Water Balance

- **Real Losses**
  - Leakage & Overflows at Storage

- **Apparent Losses**
  - Leakage on Service Lines (before the meter)
  - Leakage on Mains
  - Customer Metering & Data Inaccuracies

- **Unbilled Authorized Consumption**
  - Unauthorized Consumption
  - Unbilled Unmetered Consumption
  - Unbilled Metered Consumption

- **Billed Authorized Consumption**
  - Billed Metered Consumption
  - Billed Unmetered Consumption

- **Non-Revenue Water**
  - Leakage on Mains
  - Leakage on Service Lines (before the meter)
  - Leakage & Overflows at Storage

- **System Input**
  - Water Imported
  - Own Sources
  - Total System Input

- **Water Losses**
  - Real Losses
  - Apparent Losses
  - Unbilled Authorized Consumption

- **Authorized Consumption**
  - Billed Authorized Consumption
  - Billed Water Exported

- **Water Exported**
  - Billed Water Exported
  - Unbilled Water Exported

- **Water Supplied**
  - Billed Water Supplied

- **Authorized Water**
  - Billed Authorized Water

- **Unbilled Water**
  - Unbilled Authorized Water

- **Total Authorized Consumption**

- **Total System Input**

- **Total Authorized Consumption**

- **Real Losses**

- **Apparent Losses**

- **Unbilled Authorized Consumption**

- **Billed Authorized Consumption**

- **Billed Water Exported**

- **Unbilled Water Exported**

- **Billed Water Supplied**

- **Billed Authorized Water**

- **Unbilled Authorized Water**

- **Total Authorized Consumption**

- **Water Imported**

- **Own Sources**
Real Losses
- Physical loss - leakage
- Tools for control include leakage and pressure management

Apparent Losses
- Non-physical / revenue loss - slow meters, billing issues and theft
- Tools for control include data management, quality control policies/practices, & meter testing & repair

Non-Revenue Water
- Fire Dept Usage
- Operational flushing
- Tools for control include efficient flushing practices and awareness campaigns

QUIZ
- Fire Department flushing
- Under registering customer meters
- Pipe joint leakage
- Water theft
- Customer billing adjustment
- DOT usage
- AMR device transmission failure
- Customer toilet leak
- Water main break
- Storage tank overflows
Quiz

According to the AWWA M36 Water Audit Method, an acceptable level of Unaccounted For Water is:

A. 15%
B. 5%
C. 0%
D. 10%
Water Loss or NRW as % of Supply

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

- Water Supplied (MGD)
- Authorized Consumption (MGD)
- Water Loss (MGD)

Development Boom
Great Recession, Rate Increases, Conservation
New Normal
Simplicity
Everything should be made as simple as possible, but no simpler.
-A. Einstein

For every complex problem, there is a solution which is simple, neat, and wrong.
-H.L. Mencken

3-V
Volume
MG per Year
Gal/connection/day
Leakage Index

Value
$ per Year
Economic Loss Index

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

<table>
<thead>
<tr>
<th>Volume</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>NRW Components - By Volume (MG) - Level 2</td>
<td>NRW Components - By Value Level 2</td>
</tr>
</tbody>
</table>
Infrastructure Leakage Index

ILI

ILI = CARL (current leakage)
UARL (technical low leakage limit at current pressure)

Basic Concepts

1. Utilize the Water Balance.
2. Separate Total Water Loss into Real and Apparent Loss.
3. Separate Real and Apparent Loss into their subcomponents.
4. Use metrics in units of Volume, Value & Validity to make your game plan.
Today's Workshop

Warmup

Foundations - Top Down M36 Water Audit
Foundations - Developing the Inputs
Exercise - Top Down M36 Water Audit

Foundations – Data Validation
Exercise - Data Validation

Next Steps for Audit to Action

Critical Importance of Validation

California

<table>
<thead>
<tr>
<th>State</th>
<th>Negative Water Losses</th>
<th>Number of Audits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA</td>
<td>7%</td>
<td>5%</td>
</tr>
<tr>
<td>CA</td>
<td>4%</td>
<td>7%</td>
</tr>
<tr>
<td>CA</td>
<td>2%</td>
<td>3%</td>
</tr>
<tr>
<td>CA</td>
<td>3%</td>
<td>5%</td>
</tr>
<tr>
<td>CA</td>
<td>5%</td>
<td>7%</td>
</tr>
<tr>
<td>CA</td>
<td>6%</td>
<td>8%</td>
</tr>
<tr>
<td>CA</td>
<td>7%</td>
<td>9%</td>
</tr>
<tr>
<td>CA</td>
<td>8%</td>
<td>10%</td>
</tr>
<tr>
<td>CA</td>
<td>9%</td>
<td>11%</td>
</tr>
<tr>
<td>CA</td>
<td>10%</td>
<td>12%</td>
</tr>
</tbody>
</table>

Texas

<table>
<thead>
<tr>
<th>State</th>
<th>Negative Water Losses</th>
<th>Number of Audits</th>
</tr>
</thead>
<tbody>
<tr>
<td>TX</td>
<td>7%</td>
<td>5%</td>
</tr>
<tr>
<td>TX</td>
<td>4%</td>
<td>7%</td>
</tr>
<tr>
<td>TX</td>
<td>2%</td>
<td>3%</td>
</tr>
<tr>
<td>TX</td>
<td>3%</td>
<td>5%</td>
</tr>
<tr>
<td>TX</td>
<td>5%</td>
<td>7%</td>
</tr>
<tr>
<td>TX</td>
<td>6%</td>
<td>8%</td>
</tr>
<tr>
<td>TX</td>
<td>7%</td>
<td>9%</td>
</tr>
<tr>
<td>TX</td>
<td>8%</td>
<td>10%</td>
</tr>
<tr>
<td>TX</td>
<td>9%</td>
<td>11%</td>
</tr>
<tr>
<td>TX</td>
<td>10%</td>
<td>12%</td>
</tr>
</tbody>
</table>

Georgia:

<table>
<thead>
<tr>
<th>State</th>
<th>Negative Water Losses</th>
<th>Number of Audits</th>
</tr>
</thead>
<tbody>
<tr>
<td>GA</td>
<td>7%</td>
<td>5%</td>
</tr>
<tr>
<td>GA</td>
<td>4%</td>
<td>7%</td>
</tr>
<tr>
<td>GA</td>
<td>2%</td>
<td>3%</td>
</tr>
<tr>
<td>GA</td>
<td>3%</td>
<td>5%</td>
</tr>
<tr>
<td>GA</td>
<td>5%</td>
<td>7%</td>
</tr>
<tr>
<td>GA</td>
<td>6%</td>
<td>8%</td>
</tr>
<tr>
<td>GA</td>
<td>7%</td>
<td>9%</td>
</tr>
<tr>
<td>GA</td>
<td>8%</td>
<td>10%</td>
</tr>
<tr>
<td>GA</td>
<td>9%</td>
<td>11%</td>
</tr>
<tr>
<td>GA</td>
<td>10%</td>
<td>12%</td>
</tr>
</tbody>
</table>

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

September 2015

Critical Importance of Validation

California

<table>
<thead>
<tr>
<th>State</th>
<th>Negative Water Losses</th>
<th>Number of Audits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA</td>
<td>7%</td>
<td>5%</td>
</tr>
<tr>
<td>CA</td>
<td>4%</td>
<td>7%</td>
</tr>
<tr>
<td>CA</td>
<td>2%</td>
<td>3%</td>
</tr>
<tr>
<td>CA</td>
<td>3%</td>
<td>5%</td>
</tr>
<tr>
<td>CA</td>
<td>5%</td>
<td>7%</td>
</tr>
<tr>
<td>CA</td>
<td>6%</td>
<td>8%</td>
</tr>
<tr>
<td>CA</td>
<td>7%</td>
<td>9%</td>
</tr>
<tr>
<td>CA</td>
<td>8%</td>
<td>10%</td>
</tr>
<tr>
<td>CA</td>
<td>9%</td>
<td>11%</td>
</tr>
<tr>
<td>CA</td>
<td>10%</td>
<td>12%</td>
</tr>
</tbody>
</table>

Texas

<table>
<thead>
<tr>
<th>State</th>
<th>Negative Water Losses</th>
<th>Number of Audits</th>
</tr>
</thead>
<tbody>
<tr>
<td>TX</td>
<td>7%</td>
<td>5%</td>
</tr>
<tr>
<td>TX</td>
<td>4%</td>
<td>7%</td>
</tr>
<tr>
<td>TX</td>
<td>2%</td>
<td>3%</td>
</tr>
<tr>
<td>TX</td>
<td>3%</td>
<td>5%</td>
</tr>
<tr>
<td>TX</td>
<td>5%</td>
<td>7%</td>
</tr>
<tr>
<td>TX</td>
<td>6%</td>
<td>8%</td>
</tr>
<tr>
<td>TX</td>
<td>7%</td>
<td>9%</td>
</tr>
<tr>
<td>TX</td>
<td>8%</td>
<td>10%</td>
</tr>
<tr>
<td>TX</td>
<td>9%</td>
<td>11%</td>
</tr>
<tr>
<td>TX</td>
<td>10%</td>
<td>12%</td>
</tr>
</tbody>
</table>

Georgia:

<table>
<thead>
<tr>
<th>State</th>
<th>Negative Water Losses</th>
<th>Number of Audits</th>
</tr>
</thead>
<tbody>
<tr>
<td>GA</td>
<td>7%</td>
<td>5%</td>
</tr>
<tr>
<td>GA</td>
<td>4%</td>
<td>7%</td>
</tr>
<tr>
<td>GA</td>
<td>2%</td>
<td>3%</td>
</tr>
<tr>
<td>GA</td>
<td>3%</td>
<td>5%</td>
</tr>
<tr>
<td>GA</td>
<td>5%</td>
<td>7%</td>
</tr>
<tr>
<td>GA</td>
<td>6%</td>
<td>8%</td>
</tr>
<tr>
<td>GA</td>
<td>7%</td>
<td>9%</td>
</tr>
<tr>
<td>GA</td>
<td>8%</td>
<td>10%</td>
</tr>
<tr>
<td>GA</td>
<td>9%</td>
<td>11%</td>
</tr>
<tr>
<td>GA</td>
<td>10%</td>
<td>12%</td>
</tr>
</tbody>
</table>
### Georgia Statewide Water Loss Technical Assistance – Finished Water Meter Testing

<table>
<thead>
<tr>
<th>Test Verification</th>
<th>Number of Participants</th>
<th>Number of Finished Water Meters Tested</th>
<th>Number of Meters Passing Within AWWA Accuracy Limits</th>
<th>Average Under-registration of Meters Outside AWWA Accuracy Limits (%)</th>
<th>Average Over-registration of Meters Outside AWWA Accuracy Limits (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAIL</td>
<td>49%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UNTESTABLE</td>
<td>33%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PASS</td>
<td>18%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Customer Meter Testing

<table>
<thead>
<tr>
<th>Test Verification</th>
<th>Number of Participants</th>
<th>Number of Customer Meters Tested</th>
<th>Number of Meters Passing Within AWWA Accuracy Limits</th>
<th>Average Under-registration of Meters Outside AWWA Accuracy Limits (%)</th>
<th>Average Over-registration of Meters Outside AWWA Accuracy Limits (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAIL</td>
<td>8%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UNTESTABLE</td>
<td>20%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PASS</td>
<td>52%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Pilot Leak Detection

<table>
<thead>
<tr>
<th>Test Verification</th>
<th>Number of Participants</th>
<th>Number of Miles of Distribution Line Surveyed</th>
<th>Number of Leaks Found</th>
<th>Annual Leakage Volume Found (MGAL)</th>
<th>Total Annual Energy and Chemical Cost Savings From Discovered Leakage ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAIL</td>
<td>49%</td>
<td></td>
<td>520</td>
<td>$125,000</td>
<td>$138,000</td>
</tr>
<tr>
<td>UNTESTABLE</td>
<td>33%</td>
<td></td>
<td>300</td>
<td>$90,000</td>
<td>$100,000</td>
</tr>
<tr>
<td>PASS</td>
<td>18%</td>
<td></td>
<td>211</td>
<td>$70,000</td>
<td>$80,000</td>
</tr>
</tbody>
</table>

Accuracy results from MFR test bench: 99.5%
Accuracy results from in-situ test: 143.2%

Courtesy MESCO
Georgia Statewide Water Loss Technical Assistance – Customer Meter Testing (CMT)
AWWA M36 Water Audit Data Validity Scoring

In computer science, **data validation** is the process of ensuring that a program operates on clean, correct and useful data.

- AWWA developed a detailed grading matrix for Water Audit inputs
- Based on the utility's policies and practices for data collection, data management, data archiving, quality control procedures, and derivation of audit inputs
- Provides a quantitative measure of the reliability

---

**AWWA Free Water Audit Software© (V5.0)**

*Guidance on Use of Water Audit Data, based on Level of Data Validity*

<table>
<thead>
<tr>
<th>Functional Focus Area</th>
<th>Level I (0-25)</th>
<th>Level II (26-50)</th>
<th>Level III (51-70)</th>
<th>Level IV (71-90)</th>
<th>Level V (91-100)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Audit/Record Collection</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infrastructure Management</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long-term Control Program</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metering</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accounting</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analysis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**Research Information** on leak detection programs. Begin flowcharting analysis of customer billing system. Conduct loss assessment investigations on a sample portion of the system: customer meter testing, leak survey, unauthorized consumption, etc. Establish ongoing mechanisms for customer meter accuracy testing, active leakage control and infrastructure monitoring. Refine, enhance or expand ongoing programs based upon economic justification. Stay abreast of improvements in metering, meter reading, billing, leakage management and infrastructure rehabilitation.
Today's Workshop

Warmup

Foundations - Top Down M36 Water Audit
Foundations - Developing the Inputs
Exercise - Top Down M36 Water Audit

Foundations – Data Validation
Exercise - Data Validation

Next Steps for Audit to Action