Partnership for Safe Water
Distribution System Optimization Program

Barbara Martin, AWWA
Why Optimize?

• Assessment benefits:
  – System-specific learning opportunity
  – Prepare for future regulations
  – Water quality and operational improvements
  – Teamwork, communications, pride in performance
  – Positive recognition

Representatives from Fort Collins Utilities receive the Directors Award for the Distribution Program at ACE15
Outline

• Distribution System Optimization Program
  – Optimization Areas, Goals, and Data Collection
  – Self-Assessment Process
  – Initial Outcomes
Partnership for Safe Water

• Drinking water optimization and recognition program established in 1995 to address Cryptosporidium concerns

• Partner organizations:
Partnership for Safe Water

• Partnership for Safe Water mission:
  – To improve the quality of drinking water delivered to customers of community water systems by optimizing operations.

• Two programs
  – Treatment plant optimization (1995)
  – Distribution system optimization (2011)
    • 155 distribution systems
Key Distribution System Monitoring Parameters

- Disinfectant residual
  - *Water quality integrity*
- Main break frequency
  - *Physical integrity*
- Pressure management
  - *Hydraulic integrity*

Identified in WRF 4109 – Criteria for Optimized Distribution Systems
Distribution System Performance Improvement Variables

- Disinfectant Residual
- Cross-Connection Control
- Customer Complaints
- DBP Control
- Energy Management
- External Corrosion Control
- Flushing
- Hydrant and Valve Maintenance
- Internal Corrosion Control
- Main Breaks
- Nitrification
- Pipe Rehabilitation and Replacement
- Inorganic Accumulation Control
- Pressure Management
- Security and Online Monitoring
- Storage Tank O&M
- Water Age Management
- Water Loss Control
- Water Sampling and Response
Relationships Between Parameters

- Disinfectant Residual
- Pressure Control
- Main Breaks
- Energy Management
- Cross Connection Control
- Flushing
- Storage
- Water Loss Control
- Pipeline Rehab/Replace
- Internal/External Corrosion Control
- Security Emergency Mgmt
- Post Precipitation Inorg Accum
- Internal Corrosion Control
- Water Age
- Flushing
- Disinfection: Mains, Repairs
- Customer Complaints
- DBP Compliance
- Nitrification
- Micro Compliance/Sampling
- Disinfectant
- Residual
- Nitrification
- Internal Corrosion Control
- Security Emergency Mgmt
- Post Precipitation Inorg Accum
- Flushing
- Customer Complaints
- DBP Compliance
- Nitrification
- Micro Compliance/Sampling
- Security Emergency Mgmt
- Post Precipitation Inorg Accum
- Internal Corrosion Control
- Water Age
- Flushing

- Customer Complaints
- DBP Compliance
- Nitrification
- Micro Compliance/Sampling
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- Customer Complaints
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- Micro Compliance/Sampling
- Security Emergency Mgmt
- Post Precipitation Inorg Accum
- Internal Corrosion Control
- Water Age
- Flushing
Performance Goals: Disinfectant Residual

- Disinfectant Residual (>95% of meas.)
  - Free Chlorine: $\geq 0.20$ and $\leq 4.0$ mg/L
  - Total Chlorine: $\geq 0.50$ and $\leq 4.0$ mg/L
  - Chlorine Dioxide: $\geq 0.20$ and $\leq 0.80$ mg/L

- No *consecutive* residual measurements outside target concentrations at *optimized* routine sample locations

- DBPs within regulatory requirements
Disinfectant Sampling

• Optimized (high-risk) locations include:
  – Finished water entry points and metering points to other systems
  – Stage 1 and/or Stage 2 DBP sites
  – IDSE or IDSE-type sites
  – Downstream of storage facilities
  – Upstream/downstream of boosters
  – Low flow areas
  – Unlined cast iron mains
  – High HRT areas/other concerns
Performance Goals: Pressure

• Minimum Pressure ($\geq 99.5\%$ of meas.)
  – Pressure: $\geq 20$ psi for daily minimum
• Maximum pressure ($\geq 95\%$ of meas.)
  – Does not exceed utility specified maximum
• Pressure fluctuations ($\geq 95\%$ of meas.)
  – Does not exceed range specified by utility
Pressure Monitoring

- Optimized monitoring
  - Continuous pressure monitors at high and low pressure sites within each pressure zone
Performance Goals: Main Breaks

• Main Breaks and Leaks
  – ≤ 15/100 miles of pipe/year - for reported leaks and breaks in utility-controlled distribution and transmission piping

• Or – declining 5-year main break frequency trend demonstrating progress towards optimization
Program Phases

- Phase I – Commitment
- Phase II – Baseline data reporting
- Phase III – Self-Assessment completion
- Phase IV – Demonstrated optimization

Subscribers are required to comply with all applicable regulations, regardless of program Phase.
Phase II

• Submission of baseline data
  – Disinfectant residual
    • Entry point
    • Distribution system
  – Disinfection by-products

• Why? Establish baseline and measure improvement over time (start where you are)
### Partnership Tool: Disinfectant Residual Data Collection Software

**Entry Point Data Entry - Free Chlorine**

<table>
<thead>
<tr>
<th>Start Date</th>
<th>Average Daily Value</th>
<th>Average Daily Disinfectant Concentration for:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/12/2011</td>
<td>0.45</td>
<td>0.59</td>
</tr>
<tr>
<td>1/13/2011</td>
<td>0.45</td>
<td>0.59</td>
</tr>
<tr>
<td>1/14/2011</td>
<td>0.45</td>
<td>0.59</td>
</tr>
<tr>
<td>1/15/2011</td>
<td>0.45</td>
<td>0.59</td>
</tr>
<tr>
<td>1/16/2011</td>
<td>0.45</td>
<td>0.59</td>
</tr>
<tr>
<td>1/17/2011</td>
<td>0.45</td>
<td>0.59</td>
</tr>
<tr>
<td>1/18/2011</td>
<td>0.45</td>
<td>0.59</td>
</tr>
<tr>
<td>1/19/2011</td>
<td>0.45</td>
<td>0.59</td>
</tr>
<tr>
<td>1/20/2011</td>
<td>0.45</td>
<td>0.59</td>
</tr>
<tr>
<td>1/21/2011</td>
<td>0.45</td>
<td>0.59</td>
</tr>
</tbody>
</table>

**Secondary Residual Disinfectant - free chlorine or total chlorine or chlorine dioxide**

**Applicable Routine Sample Goals - free chlorine ≥ 0.20 mg/L and ≤ 4.0 mg/L, total chlorine ≥ 0.50 mg/L and ≤ 4.0 mg/L, chlorine dioxide ≥ 0.20 mg/L and ≤ 0.80 mg/L**

<table>
<thead>
<tr>
<th>Entry Points Residual Average (mg/L)</th>
<th>Annual</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.45</td>
<td>0.45</td>
<td>0.45</td>
<td>0.45</td>
<td>0.45</td>
<td>0.45</td>
<td>0.45</td>
<td>0.45</td>
<td>0.45</td>
<td>0.45</td>
<td>0.45</td>
<td>0.45</td>
<td>0.45</td>
</tr>
</tbody>
</table>

| Number of Routine Samples | 730   | 62  | 56  | 52  | 60  | 52  | 60  | 52  | 60  | 50  | 62  | 50  | 62  |

| Number of Routine Test Results Not meeting Goals | 3     | 3    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    |

| % Routine Test Results Not meeting Goals | 0.41% | 4.84% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |

| Minimum Daily Residual Value (mg/L) | 0.18   | 0.18 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 |

| Number of repeat non-conforming sites | 0     | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    |

### TTHM Maximum (µg/L)

| TTHM Maximum (µg/L) | 0.00   |

| HAA5 Maximum (µg/L) | 0.00   |
### Partnership Tool: Pressure Monitoring Software

#### Pressure Data Summary Table

<table>
<thead>
<tr>
<th></th>
<th>Annual</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Daily Minimum &lt; 20psi</td>
<td>0.5</td>
<td>6.5</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>% Daily Maximum &gt; goal</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>% Daily Single Site Range &gt; goal</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Average Daily System Min.</td>
<td>21.9</td>
<td>20.8</td>
<td>22.0</td>
<td>22.0</td>
<td>22.0</td>
<td>22.0</td>
<td>22.0</td>
<td>22.0</td>
<td>22.0</td>
<td>22.0</td>
<td>22.0</td>
<td>22.0</td>
<td>22.0</td>
</tr>
<tr>
<td>Average Daily System Max.</td>
<td>45.0</td>
<td>45.0</td>
<td>45.0</td>
<td>45.0</td>
<td>45.0</td>
<td>45.0</td>
<td>45.0</td>
<td>45.0</td>
<td>45.0</td>
<td>45.0</td>
<td>45.0</td>
<td>45.0</td>
<td>45.0</td>
</tr>
<tr>
<td>Average Daily System Range (Max)</td>
<td>23.0</td>
<td>23.0</td>
<td>23.0</td>
<td>23.0</td>
<td>23.0</td>
<td>23.0</td>
<td>23.0</td>
<td>23.0</td>
<td>23.0</td>
<td>23.0</td>
<td>23.0</td>
<td>23.0</td>
<td>23.0</td>
</tr>
<tr>
<td>Avg. Number Pressure Sensor Locations in Service</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Number of Pressure sensors below 20</td>
<td>2.0</td>
<td>2.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Number of Pressure Sensor locations Repeatedly below 20 psi</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Data includes: number of sensors, daily minimum, daily maximum, single site max range
# Partnership Tool: Main Breaks Software

## System-wide Analysis Table

<table>
<thead>
<tr>
<th>ID</th>
<th>Year Range</th>
<th>Reported Breaks and Leaks</th>
<th>Miles of Pipe</th>
<th>Reported Events Per 100 Miles of Pipe</th>
<th>Criteria</th>
<th>Linear Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average</td>
<td>1999 to 2012</td>
<td>1899 to 2012</td>
<td>1999 to 2012</td>
<td>1999</td>
<td></td>
</tr>
</tbody>
</table>

### Summary Data

<table>
<thead>
<tr>
<th>ID</th>
<th>Year</th>
<th>Reported Breaks and Leaks</th>
<th>Miles of Pipe</th>
<th>Reported Events Per 100 Miles of Pipe</th>
<th>Criteria</th>
<th>Linear Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1999</td>
<td>739</td>
<td>5,500.0</td>
<td>13.4</td>
<td>15</td>
<td>35.47</td>
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<tr>
<td>2</td>
<td>2000</td>
<td>702</td>
<td>1,777.0</td>
<td>39.5</td>
<td>15</td>
<td>33.08</td>
</tr>
<tr>
<td>3</td>
<td>2001</td>
<td>553</td>
<td>1,780.0</td>
<td>31.1</td>
<td>15</td>
<td>30.70</td>
</tr>
<tr>
<td>4</td>
<td>2002</td>
<td>522</td>
<td>1,783.0</td>
<td>29.3</td>
<td>15</td>
<td>28.31</td>
</tr>
<tr>
<td>5</td>
<td>2003</td>
<td>582</td>
<td>1,785.0</td>
<td>32.6</td>
<td>15</td>
<td>25.92</td>
</tr>
<tr>
<td>6</td>
<td>2004</td>
<td>601</td>
<td>1,787.0</td>
<td>33.6</td>
<td>15</td>
<td>23.53</td>
</tr>
<tr>
<td>7</td>
<td>2005</td>
<td>495</td>
<td>1,789.0</td>
<td></td>
<td>15</td>
<td></td>
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<tr>
<td>8</td>
<td>2006</td>
<td>454</td>
<td>1,791.0</td>
<td></td>
<td>15</td>
<td></td>
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<tr>
<td>9</td>
<td>2007</td>
<td>512</td>
<td>5,000.0</td>
<td></td>
<td>15</td>
<td></td>
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<tr>
<td>10</td>
<td>2008</td>
<td>542</td>
<td>5,000.0</td>
<td></td>
<td>15</td>
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<td>11</td>
<td>2009</td>
<td>1,070</td>
<td>5,000.0</td>
<td></td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>2010</td>
<td>200</td>
<td>5,000.0</td>
<td></td>
<td>15</td>
<td></td>
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<tr>
<td>13</td>
<td>2011</td>
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<td>5,005.0</td>
<td></td>
<td>15</td>
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</tr>
<tr>
<td>14</td>
<td>2012</td>
<td>5</td>
<td>5,005.0</td>
<td></td>
<td>15</td>
<td></td>
</tr>
</tbody>
</table>

Notes: (1) N/D = Not Data; "-" = Zero
(2) Minimum and maximum cells show the value and year of the minimum and maximum values.
(3) Criteria refers to occurrences per 100 miles of pipe.
Partnership Tool: Annual Report

- Data is summarized in the Partnership’s Annual Data Summary Report
- Compare performance with aggregate data of participating systems
- Quantifies long-term program progress

Subscriber frequency distribution of entry point average concentrations for total chlorine systems.
Phase III - Self-Assessment

• Self-Assessment is program foundation
• Objectives
  – Identify performance limiting factors
  – Create action plans to address these factors
  – Work towards achieving optimization
  – Document and track ongoing performance

Self-Assessment is a **team** effort – ideally involving individuals from across the organization.
Phase III - Self-Assessment

• Self-Assessment of:
  – Performance and processes against optimization standards:
    • Performance criteria (disinfection, pressure, breaks)
    • Performance improvement variables
  – System design
    • Asset management
  – System operation
    • Process control
  – Administration
# Phase III – Self-Assessment Data

## Self-Assessment Data Requirements

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum daily disinfectant residual for 12 months at distribution system routine sample locations, storage tanks, and entry points. Use Data Collection Software provided by the PSW.</td>
<td></td>
</tr>
<tr>
<td>All TTHM and HAA5 routine test results for 12 months. Annual DBP trending indicating RAA. Use PSW software.</td>
<td></td>
</tr>
<tr>
<td>Daily minimum pressure readings from permanent sensors for the most recent 12 months – ideally at 2 locations in each pressure zone (low and high). Use PSW software.</td>
<td></td>
</tr>
<tr>
<td>Main break records for several years – 10 years is ideal. Use PSW software.</td>
<td></td>
</tr>
<tr>
<td>Records of the annual number of technical water quality complaints. Record of the number of accounts for the utility.</td>
<td></td>
</tr>
<tr>
<td>Flushing velocity, disinfectant residual (before and after), for procedures that are initiated to correct low disinfectant residuals.</td>
<td></td>
</tr>
<tr>
<td>Valve and hydrant exercise (inspection) records with the total number in the system and the number exercised annually.</td>
<td></td>
</tr>
<tr>
<td>Hydrant repair record and calculated time to restore service after detection.</td>
<td></td>
</tr>
<tr>
<td>Internal corrosion testing practices with the number of tests performed annually.</td>
<td></td>
</tr>
<tr>
<td>Free ammonia, nitrate, nitrite, results summary for distribution systems using chloramines.</td>
<td></td>
</tr>
</tbody>
</table>
### Phase III - Self-Assessment Data

<table>
<thead>
<tr>
<th>Self-Assessment Data Requirements (Continued)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipeline renewal and replacement rate. The annual miles of pipeline replaced and the miles of pipe in the entire distribution system. The miles of unlined metal pipe and the miles replaced. The miles of pipe more than 75 years old.</td>
</tr>
<tr>
<td>Storage tank cleaning records that show the frequency and any observations</td>
</tr>
<tr>
<td>Water age records at key sites demonstrating the annual maximum water age</td>
</tr>
<tr>
<td>Calculation of the volume of annual real losses, real losses expressed as gallons/service connections/day, and ILI using the AWWA/IWA water audit method.</td>
</tr>
<tr>
<td>Distribution system schematic (map)</td>
</tr>
<tr>
<td>Asset inventory</td>
</tr>
<tr>
<td>Distribution system pipeline type inventory and installation dates</td>
</tr>
<tr>
<td>Storage facility type and installation dates</td>
</tr>
<tr>
<td>Pump type, size, and installation dates</td>
</tr>
<tr>
<td>Valve and hydrant number and installation dates</td>
</tr>
<tr>
<td>Calculations for the following benchmarks (reporting is optional): debt ratio, O&amp;M cost per account, system renewal rate, training hours per employee, interest % of budget</td>
</tr>
</tbody>
</table>
## Phase III: Example Questions

### Disinfectant Residual

<table>
<thead>
<tr>
<th>Self-Assessment Category</th>
<th>Questions for Gauging Optimization Status</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Individual Site Testing</strong></td>
<td>Does the utility have a system sampling map? Are sample collection sites representative of the overall distribution system? Does the utility track sites that repeatedly have low disinfectant residuals? Are performance improvement variables (chapter 3) used to reduce low residual recurrence? Are non-routine low residual sites added to the next year’s routine sample location schedule? Are there any consecutive disinfectant residual measurements at optimized routine sample locations below the residual goals?</td>
</tr>
<tr>
<td><strong>Residual Test Methods and Procedures</strong></td>
<td>Is disinfectant residual testing performed using approved methods and digital testing equipment? Are values recorded to two decimal places? Are there on-line continuous monitors in use throughout the distribution system? Is data collected and continuously displayed for operators by the SCADA system?</td>
</tr>
<tr>
<td><strong>Chlorine and Chloramine Interaction</strong></td>
<td>Does the system monitor and operate to minimize odors and other interaction by-products? Is free ammonia monitored where interaction may cause breakpoint issues?</td>
</tr>
</tbody>
</table>
## Phase III: Example Questions Valve, Hydrant, Blowoff Maintenance

<table>
<thead>
<tr>
<th>Self-Assessment Category</th>
<th>Questions for Gauging Optimization Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location Records</td>
<td>Does the system have accurate and current records that document the location and attributes for all valves, hydrants, and blowoffs?</td>
</tr>
<tr>
<td>Inspection and Assessment</td>
<td>Are all valves, hydrants, and blowoffs inspected and evaluated on a schedule?</td>
</tr>
<tr>
<td>Exercise Program</td>
<td>Are all distribution system main valves and hydrants exercised and tested at least every three years (or more frequently if required by regulation)?</td>
</tr>
<tr>
<td>Hydrant Repairs</td>
<td>Are all hydrant repairs scheduled within 24 hours of discovery? Are inoperable hydrants identified immediately and is this communicated to the fire protection authority?</td>
</tr>
<tr>
<td>Hydrant Access</td>
<td>Does the system control access to hydrants and provide training for proper third-party use?</td>
</tr>
</tbody>
</table>
Phase III - Action Plan Development

- Action plans developed for high priority areas that are not optimized/partially optimized
- Utilities should not hesitate to act!

<table>
<thead>
<tr>
<th>Self-Assessment Category</th>
<th>Issue</th>
<th>Short Term Solution</th>
<th>Person(s) Responsible</th>
<th>Target Date</th>
<th>Long Term Solution</th>
<th>Person(s) Responsible</th>
<th>Target Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>On-line Chlorine Monitor and SCADA Display</td>
<td>Additional online chlorine residual analyzers would provide valuable data</td>
<td>Finalize identification of key areas of distribution system for analyzer placement</td>
<td>Full Team, Consensus Decision Needed</td>
<td>Apr 2013</td>
<td>Install analyzers and connect with SCADA</td>
<td>Dist System Maintenance Supervisor</td>
<td>April 2014</td>
</tr>
<tr>
<td></td>
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<td>Budget for and purchase 3 analyzers</td>
<td>Distribution System Ops. Super-Intendent</td>
<td>Jan 2014</td>
<td>Review analyzer data trends for optimization opportunities</td>
<td>Treatment Plant and Distribution System Lead Operators</td>
<td>Ongoing, incorp. Into SOPs</td>
</tr>
</tbody>
</table>
Partnership Tools: Self-Assessment

- Self-assessment guide
- Tracking and prioritization software tools
- Report checklist
- Report template
- Example report
- Assistance and mentorship from utilities and staff
Phase III - Directors Award

Long Beach Water Department (CA)
Distribution System Self-Assessment Team
Was a 2013 Directors Award Recipient
Distribution System Self-Assessment Outcomes

- 16 self-assessments completed to date
- Chlorine and chloramine systems
- Retail, wholesale, and consecutive systems
- Population range:
  - 12,000 with <100 miles of pipe to more than 18,000,000
- Self-paced process – most take about 12 months
# Top Self-Assessment Actions

<table>
<thead>
<tr>
<th>Top Self-Assessment Report Actions</th>
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<tbody>
<tr>
<td>Hydraulic model calibration/availability</td>
</tr>
<tr>
<td>Pressure monitoring</td>
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<tr>
<td>Pump efficiency testing</td>
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<tr>
<td>Optimize flushing</td>
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<tr>
<td>Asset management</td>
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</table>
Self-Assessment Summary

- Self-assessment has helped to:
  - Identify and address performance limiting factors in system to improve operations and water quality
  - Better understanding/centralizing available data
  - Improve accountability and engagement
  - Most significantly:
    - Utilities that identify performance limiting factors are taking immediate action to address them and make improvements!
Questions?

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