Distribution System Upgrades to Improve Water Quality

Christopher Evans, P.E., Hatch Mott MacDonald
Outline

• Replace Water Lines Project
  – Project Purpose
  – Study Phase
    • Utility Source Evaluation
    • Elevated Storage Tank Evaluation
    • Plumbing System Evaluation
    • Distribution System Evaluation
    • Hydraulic Model
  – Design Phase
  – Construction Phase
  – Conclusions
Project Purpose

- Harrisburg, Pennsylvania Vicinity
- Project Driver – Brown Water Quality Complaints
  - Consecutive Distribution System
    - Purchase Water From Utility
    - Booster Pump Station / Chlorine Booster Station
    - 250,000 Gallon Elevated Storage Tank
  - Business Campus
    - Established in 1947
    - Business Model Changes - Large Reduction in Water Demand
Project Purpose

• Project Scope
  – 20,040 Linear Feet of Distribution System – Investigate Condition
  – 6 Buildings (18 Stories) - Investigate Plumbing Condition

• Identify Source of Brown Water Quality & Design Upgrade
  – Utility Source Evaluation
  – Elevated Storage Tank Evaluation
  – Distribution System Evaluation
  – Plumbing System Evaluation
Project Purpose

- Site Plan

- Service Connection
- Elevated Storage Tank
- Booster Pump Station
- Site Plan
Project Purpose

- Site Plan

- Booster Pump Station
- Elevated Storage Tank
- Service Connection
- Blue Buildings
- Brown Water Quality Issues
## Study Phase

### Utility Source Evaluation – CCR Primary Contaminants

<table>
<thead>
<tr>
<th>Contaminant</th>
<th>Violation (Y/N)</th>
<th>Level Detected</th>
<th>Range</th>
<th>MCLG/MRDL</th>
<th>MCL/ MRDL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Coliform Bacteria</td>
<td>N</td>
<td>0% of samples positive</td>
<td>0</td>
<td>0</td>
<td>5%</td>
</tr>
<tr>
<td>Turbidity (NTU)</td>
<td>N</td>
<td>100% of samples &lt;0.1</td>
<td>0.04 to 0.07</td>
<td>n/a</td>
<td>TT = 95% of samples &lt;0.3</td>
</tr>
<tr>
<td>Chlorine (Entry Point) (ppm)</td>
<td>N</td>
<td>1.43</td>
<td>1.43 to 1.62</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Chlorine (Distribution System) (ppm)</td>
<td>N</td>
<td>1.51 (a)</td>
<td>1.37 to 1.51 (a)</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Copper (ppm) (2010)</td>
<td>N</td>
<td>0.0097 (b)</td>
<td>(c)</td>
<td>1.3</td>
<td>AL=1.3</td>
</tr>
<tr>
<td>Fluoride (ppm)</td>
<td>N</td>
<td>0.99 (d)</td>
<td>0.95 to 1.02 (a) (f)</td>
<td>2 (e)</td>
<td>2 (e)</td>
</tr>
<tr>
<td>Haloacetic Acids (HAA5) (ppb)</td>
<td>N</td>
<td>16.1 (g)</td>
<td>11.1 to 25.8 (h)</td>
<td>n/a</td>
<td>60</td>
</tr>
<tr>
<td>Lead (ppb) (2010)</td>
<td>N</td>
<td>0.0000 (b)</td>
<td>(c)</td>
<td>0</td>
<td>AL=15</td>
</tr>
<tr>
<td>Nitrate (ppm)</td>
<td>N</td>
<td>0.20</td>
<td>n/a</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Arsenic (ppm)</td>
<td>N</td>
<td>0.0000</td>
<td>n/a</td>
<td>n/a</td>
<td>0.010</td>
</tr>
<tr>
<td>Total Organic Carbon (ppm)</td>
<td>N</td>
<td>1.3 (g)</td>
<td>0.95 to 2.2 (g)</td>
<td>n/a</td>
<td>TT &lt;2.0</td>
</tr>
<tr>
<td>Total Trihalomethanes (TTHMs) (ppb)</td>
<td>N</td>
<td>49.8 (g)</td>
<td>26.1 to 100.0 (h)</td>
<td>n/a</td>
<td>80</td>
</tr>
</tbody>
</table>
### Study Phase

- **Utility Source Evaluation – CCR Secondary Contaminants**

<table>
<thead>
<tr>
<th>Contaminant (Unit of measurement)</th>
<th>Violation (Y/N)</th>
<th>Level Detected (a)</th>
<th>Range (b)</th>
<th>Recommended Limit (c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkalinity (ppm)</td>
<td>N</td>
<td>24</td>
<td>19 to 32</td>
<td>n/a</td>
</tr>
<tr>
<td>Aluminum (ppb)</td>
<td>N</td>
<td>71</td>
<td>60 to 80</td>
<td>200</td>
</tr>
<tr>
<td>Hardness (ppm)</td>
<td>N</td>
<td>49</td>
<td>40 to 57</td>
<td>Soft Water &lt; 75</td>
</tr>
<tr>
<td>Iron (ppb)</td>
<td>N</td>
<td>13</td>
<td>10 to 20</td>
<td>Hard Water &gt; 150</td>
</tr>
<tr>
<td>Manganese (ppb)</td>
<td>N</td>
<td>8</td>
<td>0 to 10</td>
<td>300</td>
</tr>
<tr>
<td>pH</td>
<td>N</td>
<td>9.9 (d)</td>
<td>9.8 to 9.9 (d)</td>
<td>6.5 - 8.5</td>
</tr>
<tr>
<td>Sulfate (ppm) (2004)</td>
<td>N</td>
<td>26</td>
<td>n/a</td>
<td>250</td>
</tr>
</tbody>
</table>

- **Fe & Mn Normal Ranges**
- **pH Abnormally High**

(a) Annual average value.
(b) Monthly average values.
(c) Recommended limits on compounds that might be a nuisance to the customer. These compounds affect aesthetic quality (appearance, taste, odor, etc.), but do not pose a health risk.
(d) A higher pH is maintained to help control corrosion in the distribution system mains and is approved by the State Dept of Environmental Protection.
Study Phase

- Utility Source Evaluation – Distribution Samples
  - Fe Normal Range – 0.01 to 0.04 ppb
  - Mn Normal Range – 0.00 to 0.04 ppb

- Elevated Storage Tank Evaluation
  - Recent inspection
    - No solids accumulation
    - Interior coating needed replacement
  - Tank not considered source
  - Tank scheduled for replacement
• Water Quality Sampling Event

• Service Connection Samples
  – Fe (Total) – 0.48 ppm
  – Mn – 0.02 ppm

• 10 Sample Locations
  – Plumbing & Distribution System
  – Fe (Total) Range – 0.48 to 4.8 ppm
  – Mn Range – 0.02 to 0.33 ppm
• Plumbing System Evaluation

Galvanized Pipe
- 60 Years of Service
Study Phase

- Distribution System Evaluation – Bone Yard

Transite Pipe - 60 Years of Service
• Distribution System Evaluation

Study Phase

Condition Assessment—Spool Piece

Unlined Cast Iron Pipe - 60 Years of Service

PA AWWA Annual Conference
May 6th – 8th, 2014
Bethlehem, PA
Study Phase

• Distribution System Evaluation
• Limited Distribution System Understanding
  – Pipe Material: Yes
  – Pipe Diameter: Yes
  – Interior Lining: No
  – Exterior Coating: No
  – Pipe Condition: No
  – Year Installed: 30 Year Accuracy
  – Water Quality: No
  – Soil Conditions: No
  – Break History: No
  – Non-Revenue Water: No
  – Renewal Rate: No

• Construct Distribution System Map / GIS Database
Study Phase

- Distribution System Evaluation

Transite (ACP) – 1947
Unlined Metallic – After 1947
DIP Cement Lined – After 2000
Study Phase

- Distribution System Evaluation

Blue Buildings

Brown Water Quality Issues
### Study Phase

- **Hydraulic Model**

<table>
<thead>
<tr>
<th>Diameter</th>
<th>Length (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\leq 4''$</td>
<td>3,955</td>
</tr>
<tr>
<td>6''</td>
<td>4,880</td>
</tr>
<tr>
<td>8''</td>
<td>2,915</td>
</tr>
<tr>
<td>10''</td>
<td>3,525</td>
</tr>
<tr>
<td>12''</td>
<td>4,765</td>
</tr>
<tr>
<td><strong>Total Pipe</strong></td>
<td><strong>20,040</strong></td>
</tr>
</tbody>
</table>

- **Cement Lined Ductile Iron**
  - 12.4%
  - 2,488 LF

- **Asbestos-Cement**
  - 22.6%
  - 4,537 LF

- **Unlined Cast Iron**
  - 65.0%
  - 13,016 LF
Study Phase

- Hydraulic Model
  - C Value Tests
- Gauge Health
- Calibrate Model
Study Phase

- Hydraulic Model – C Value Tests

**Start**

**10 Minutes**
### Hydraulic Model – C Value Tests

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Pipe Material</th>
<th>Pipe Diameter</th>
<th>Calculated C-Value</th>
<th>Design C-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Asbestos-Cement</td>
<td>8&quot;</td>
<td>126</td>
<td>140</td>
</tr>
<tr>
<td>2</td>
<td>Cast Iron</td>
<td>12&quot;</td>
<td>32</td>
<td>100</td>
</tr>
<tr>
<td>3</td>
<td>Cast Iron</td>
<td>10&quot;</td>
<td>40</td>
<td>100</td>
</tr>
<tr>
<td>4</td>
<td>Cast Iron</td>
<td>8&quot;</td>
<td>53</td>
<td>100</td>
</tr>
<tr>
<td>5</td>
<td>Cast Iron</td>
<td>10&quot;</td>
<td>40</td>
<td>100</td>
</tr>
<tr>
<td>6</td>
<td>Asbestos-Cement and Cast Iron</td>
<td>6&quot;</td>
<td>83</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Study Phase

- Hydraulic Model – **Existing Available Fire Flow**
  - Maximum Day Demand
  - 20 psi Min. Pressure
  - Available Fire Flow
    - 12 of 36 < 1,500 gpm
Study Phase

- Hydraulic Model – **Proposed Available Fire Flow**
  - Fire Flow > Domestic Demand
  - Maximum Day Demand
  - 20 psi Min. Pressure
  - Available Fire Flow
    - All 36 > 2,500 gpm

Yellow = Proposed Cleaning & Lining
Design Phase

• Recommended a Tiered Approach
  – Tier 1 – Water Quality Monitoring Program
    • Baseline Water Quality
    • Monitor Upgrade Water Quality Improvements
  – Tier 2 – Watermain Upgrades
    • Fire Flow > Domestic Demand
    • Watermains Oversized for Domestic Demands
    • 6-inch Diameter and Larger – Cleaning & Lining
    • 4-inch Diameter and Smaller – Replacement
  – Tier 3 – Building Plumbing Upgrades
    • Select highest priority building
Why Cleaning and Lining?

**Pros**
- Cost Savings
- Time Savings
- Less Disruption

**Cons**
- Risk
- Unknown Subsurface Conditions
- Unknown Pipe Condition

Typically Cheaper to Repair Than Replace Pipe

Pipe Diameter Increase – Rehabilitation Cost Savings Increase
Design Phase

- Cleaning & Lining Project Requirements?
- Access Pits – Every 500 to 700 Linear Feet
- Access Pit Typical Locations
  - In Line Valves
  - Side Line Mains
  - Hydrant Laterals
  - Fittings
    - 22 ½ to 90 Degree Elbows
    - Pipe Diameter Change
**Recommendations**

- **Phased Construction**
  - Rehabilitation by Cleaning and Lining
  - 7,500 linear feet of Cleaning and Cement Mortar Lining
  - 1,200 linear feet of service connection replacement
  - Base Bid
  - Bid Alternates to control contract upper limit

Source: Heitkamp, Inc.
Construction Phase

- Install Bypass Pipe
- Disinfect Bypass Pipe / Bacteria Test
- Install Bypass Service Connections
Construction Phase

- Excavate Access Pits
- Isolate Water Main
- Remove Water Main From Service
- Cut Water Main At Access Pits
- Rehabilitate Water Main – Cleaning & Cement Mortar Lining
Construction Phase

Cleaning Scrapers

Tuberculation Removal at Access Pit
Construction Phase

- Repair Water Main At Access Pits
- Disinfect Water Main / Bacteria Test
- Restore Water Main Service Connections
- Remove Bypass
- Road Restoration At Access Pits
Conclusions

• Rehabilitation Versus Replacement
  – Project Specific Comparison Recommended

• Cleaning & Cement Mortar Lining
  – Cost Savings
  – Accomplished Client Goals of Reducing Brown Water Quality
  – Extends Watermain Service Life

• Client In Process of Removing Bottled Water Stations
Acknowledgment

- Herb Spencer, Shannon Chemical Corporation
- HMM Staff
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  - Kate Greising
  - Mike DeNichilo
Questions

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