ADAPTIVE CAPITAL IMPROVEMENT PLANNING AT KANSAS CITY, MISSOURI

BRIAN LENDT, GISP
B&V SR. GIS SPECIALIST

ADRIANNE BLACK
B&V SR. GIS SPECIALIST

PAUL GINThER, GISP
B&V GIS DEPARTMENT HEAD

ESRI INTERNATIONAL USER CONFERENCE
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AGENDA

• Project Background
• Adaptive CIP Prioritization
• iCIP Cost-Estimating Tool
• Demo
• Closing
PROJECT BACKGROUND
KANSAS CITY, MISSOURI – DISTRIBUTION SYSTEM OVERVIEW

- Water Services Division (WSD)
- Miles of water mains: 2,700
- Oldest mains from 1870s
- Water treated per day: 176 MGD
- Supplies 44 billion gallons annually
- Black & Veatch providing engineering services since 1910
PROJECT BACKGROUND

- Comprehensive Water System Master Plan Update: Phase I
- Distribution System Leak Detection Evaluations
- Review and Update of Water Demand Forecasts
- Conceptual Design of Raw Water Supply to Existing Water Treatment Plant
- WTP Assessments and Evaluations
PROJECT BACKGROUND, CONT.

- Alternative Water Supply and Treatment Evaluation
- Distribution System Hydraulic Model Construction and Calibration, and Analysis
- Distribution System Infrastructure Evaluation
- Drivers:
  - WDS spends significant portion of budget on water main repair
  - Directive from Mayor and City Council
INDUSTRY FOCUS IS CHANGING: EXPANSION → ASSET MANAGEMENT & OPTIMIZATION

- Need for cost-effective assessments
- Address worst condition pipelines first
- Risk based prioritization
ADAPTIVE CIP PRIORITIZATION
CIP PRIORITIZATION - OLD APPROACH

Traditional CIP

- Not risk-based
- Static CIP Report
- Time and situation constrained
- Not adaptable
CIP PRIORITIZATION – ADAPTIVE APPROACH

Adaptive CIP

- Elevate awareness
- Leverage risk-based prioritization
- Interactive and dynamic
- Enhanced scenario management
- Geographic interface
- Graphic displays
PRIORITIZING AGING INFRASTRUCTURE

Risk =

Likelihood of Failure (LoF) × Consequence of Failure (CoF)
LIKELIHOOD OF FAILURE FACTORS

- Age
- Material
- Failure History
- Geotechnical
- Contractor History
- Condition Inspection
- Available Capacity
- Exposure
- Life Expectancy
CONSEQUENCE OF FAILURE FACTORS

- Critical Customers
- Proximity to Wetlands
- Proximity to Water Supply
- Critical Area
- Number of Impacted Customers
- Sensitive Locations
- Pipe Size
- Difficulty of Repair
# KCMO: LIKELIHOOD OF FAILURE CRITERIA

<table>
<thead>
<tr>
<th>LoF Criteria</th>
<th>Strategy / Assumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohort Break Rates</td>
<td>Pipe Cohorts (663 total) • Pipe install decade • Pressure zone • Material • Diameter</td>
</tr>
<tr>
<td>Breaks on Individual Pipe Segments</td>
<td>Number of reported break repairs on pipe segment.</td>
</tr>
<tr>
<td>Considered</td>
<td>Soils: Was reviewed, but no significant trends were identified. High Traffic: Useful data was not available. Pressure Gradients: Useful data was not yet available.</td>
</tr>
<tr>
<td>Other Drivers</td>
<td>Based on input from WSD: None identified.</td>
</tr>
<tr>
<td>Total</td>
<td>Sum of above (0 to 10 scale).</td>
</tr>
</tbody>
</table>
## KCMO: CONSEQUENCE OF FAILURE CRITERIA

<table>
<thead>
<tr>
<th>CoF Criteria</th>
<th>Strategy / Assumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter</td>
<td>Larger pipe assumed to have higher consequence and cost.</td>
</tr>
<tr>
<td>Critical Customer Impact</td>
<td>Count of major users and critical customers located within 300-1000 feet of pipe segment.</td>
</tr>
<tr>
<td>Street Type</td>
<td>Score assigned based on perceived public impact, accessibility, and repair cost.</td>
</tr>
<tr>
<td>Railroads</td>
<td>Additive point if segment crosses a railroad.</td>
</tr>
<tr>
<td>Breaks on Individual Pipe Segments</td>
<td>Number of break repairs reported for pipe segment. Used in CoF as a factor due to public concern for reducing frequencies of pipe repairs.</td>
</tr>
<tr>
<td>Other Drivers</td>
<td>Based on input from WSD: Considered, but none used.</td>
</tr>
<tr>
<td>Total</td>
<td>Sum of above (0 to 10 scale).</td>
</tr>
</tbody>
</table>
**KCMO: ASSET RISK ASSESSMENT**

### Cohort

<table>
<thead>
<tr>
<th>Row Labels</th>
<th>Sum of Breaks</th>
<th>Length (Mile)</th>
<th>Breaks Per Mile</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960-SB-CIP-6</td>
<td>1345</td>
<td>88.02</td>
<td>15.28</td>
<td>6.11</td>
</tr>
<tr>
<td>1950-SB-CIP-6</td>
<td>1178</td>
<td>49.77</td>
<td>23.67</td>
<td>8.00</td>
</tr>
<tr>
<td>1950-SB-CIP-4</td>
<td>1014</td>
<td>32.47</td>
<td>31.22</td>
<td>8.00</td>
</tr>
<tr>
<td>1960-SB-CIP-8</td>
<td>704</td>
<td>66.76</td>
<td>10.54</td>
<td>4.22</td>
</tr>
<tr>
<td>1910-SD-CIP-6</td>
<td>541</td>
<td>122.15</td>
<td>4.43</td>
<td>1.77</td>
</tr>
<tr>
<td>1920-SD-CIP-6</td>
<td>537</td>
<td>74.83</td>
<td>7.18</td>
<td>2.87</td>
</tr>
<tr>
<td>1950-SD-CIP-8</td>
<td>509</td>
<td>26.17</td>
<td>19.45</td>
<td>7.78</td>
</tr>
<tr>
<td>1980-SB-DIP-6</td>
<td>445</td>
<td>30.58</td>
<td>14.55</td>
<td>5.82</td>
</tr>
<tr>
<td>1970-SB-DIP-6</td>
<td>413</td>
<td>32.46</td>
<td>12.72</td>
<td>5.09</td>
</tr>
<tr>
<td>1950-ND-CIP-6</td>
<td>408</td>
<td>17.50</td>
<td>23.32</td>
<td>8.00</td>
</tr>
<tr>
<td>1950-SD-CIP-6</td>
<td>407</td>
<td>18.48</td>
<td>22.02</td>
<td>8.00</td>
</tr>
<tr>
<td>1930-SD-CIP-6</td>
<td>389</td>
<td>24.65</td>
<td>15.76</td>
<td>6.31</td>
</tr>
</tbody>
</table>

### Main Breaks

<table>
<thead>
<tr>
<th>Number of Breaks per Pipe</th>
<th>Number of Pipes</th>
<th>Incremental Change</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3670</td>
<td>60252</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>1350</td>
<td>2320</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>666</td>
<td>684</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>387</td>
<td>279</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>242</td>
<td>145</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>185</td>
<td>57</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>75</td>
<td>43</td>
<td>3</td>
</tr>
<tr>
<td>8</td>
<td>118</td>
<td>67</td>
<td>3</td>
</tr>
<tr>
<td>9</td>
<td>58</td>
<td>17</td>
<td>3</td>
</tr>
<tr>
<td>10</td>
<td>43</td>
<td>15</td>
<td>3</td>
</tr>
<tr>
<td>11</td>
<td>36</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>12</td>
<td>32</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

LoF scoring and weighting

CoF scoring and weighting
KCMO: RISK RATING & ASSET PRIORITIZATION
### EXAMPLE: RISK-BASED CIP PRIORITIZATION

**HEAT MAP**

<table>
<thead>
<tr>
<th>Likelihood of Failure (LoF)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>$95</td>
<td>$14</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$15</td>
<td>$0</td>
<td>$1</td>
<td>$20</td>
<td>$5</td>
</tr>
<tr>
<td>9</td>
<td>$89</td>
<td>$0</td>
<td>$42</td>
<td>$52</td>
<td>$0</td>
<td>$1</td>
<td>$0</td>
<td>$10</td>
<td>$10</td>
<td>$25</td>
</tr>
<tr>
<td>8</td>
<td>$11</td>
<td>$0</td>
<td>$12</td>
<td>$0</td>
<td>$0</td>
<td>$3</td>
<td>$20</td>
<td>$2</td>
<td>$15</td>
<td>$4</td>
</tr>
<tr>
<td>7</td>
<td>$12</td>
<td>$52</td>
<td>$45</td>
<td>$0</td>
<td>$0</td>
<td>$25</td>
<td>$0</td>
<td>$22</td>
<td>$35</td>
<td>$8</td>
</tr>
<tr>
<td>6</td>
<td>$0</td>
<td>$10</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$30</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>5</td>
<td>$10</td>
<td>$22</td>
<td>$17</td>
<td>$0</td>
<td>$0</td>
<td>$25</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$30</td>
</tr>
<tr>
<td>4</td>
<td>$62</td>
<td>$6</td>
<td>$56</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>3</td>
<td>$90</td>
<td>$99</td>
<td>$10</td>
<td>$0</td>
<td>$0</td>
<td>$28</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>2</td>
<td>$25</td>
<td>$35</td>
<td>$24</td>
<td>$0</td>
<td>$10</td>
<td>$0</td>
<td>$15</td>
<td>$0</td>
<td>$0</td>
<td>$52</td>
</tr>
<tr>
<td>1</td>
<td>$45</td>
<td>$0</td>
<td>$0</td>
<td>$1</td>
<td>$0</td>
<td>$10</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
</tbody>
</table>

**Consequence of Failure (CoF)**

**Group**

- A: $95, $14, $0, $0, $15, $0, $1, $20, $5
- B: $89, $0, $42, $52, $0, $1, $0, $10, $25
- C: $11, $0, $12, $0, $0, $3, $20, $2, $15, $4
- D: $12, $52, $45, $0, $0, $25, $0, $22, $35, $8
- E: $0, $10, $0, $0, $0, $30, $0, $0, $0, $0
- F: $10, $22, $17, $0, $0, $25, $0, $0, $0, $30
- G: $62, $6, $56, $0, $0, $0, $0, $0, $0, $0
- H: $90, $99, $10, $0, $0, $28, $0, $0, $0, $0

**Example:**

- **Likelihood of Failure (LoF):** 8
- **Consequence of Failure (CoF):** $12, $52, $45, $0, $0, $25, $0, $22, $35, $8

**Group:** A

**Heat Map Color Codes:**

- Red: High Risk
- Yellow: Moderate Risk
- Green: Low Risk

**Legend:**

- A: Red
- B: Yellow
- C: Green
- D: Dark Green
- E: Very Light Purple
- F: Purple
- G: Beige
- H: Very Light Beige
ADAPT TO FUTURE CONDITION ASSESSMENT

Inspection Results

Confirmed by Inspection

Adjusted due to Inspection
KCMO RISK HEAT MAP
2014 STRATEGY GROUP BY PIPE LENGTH
KCMO RISK HEAT MAP
2014 CONCENTRATION BY PIPE LENGTH
iCIP COST-ESTIMATING TOOL
iCIP

- Interactive Capital Improvement Planning
- Built on top of ArcGIS (Esri Add-in)
- Based on Esri CIP template, enhanced by B&V
- Includes suite of tools for interactive CIP planning, budgeting and reporting
- Used for KCMO WSD infrastructure evaluation
DYNAMIC PLANNING TOOLS - COST VS. FUNCTIONALITY

COST ($)

USER INTERFACE & FUNCTIONALITY

iCIP

CapPlan

InfoMaster
WHAT ARE THE BENEFITS OF iCIP?

- Leverage risk-based prioritization and/or capacity assessments
- Graphically see immediate results of decisions
- Review multiple budget scenarios to refine R & R projects
- CIP projects can be dynamically added, removed or updated to reflect current budgets and needs
- Easy to integrate with existing GIS asset inventory
- Fully customizable and scalable
CLOSING
LESSONS LEARNED AND CLOSING

• Develop PoF / CoF criteria early on
• Involve key stake holders during development of criteria
• iCIP will help KCMO WSD to manage capacity and risk-based linear and facility CIP projects
• KCMO WSD moving forward with Phase 2 asset prioritization
  • Refine criteria
  • New break data
  • Hydraulic model data
IT COULD BE WORSE.
Building a world of difference.

Together

KC WATER SERVICES

BLACK & VEATCH
iCIP GUI
PROJECT COST ESTIMATING TOOLS

Sketch new asset

Select project area

Highlight costed asset

Import selected asset(s) for costing

Select asset for costing
PROJECT COST ESTIMATING WINDOWS

Assets window

Project Details window
PROJECT COST ESTIMATING WINDOWS

CIP Project Budget Summary
Export to Excel
(individual projects or summary of all projects)
PROJECT COST ESTIMATING WINDOWS

Project Summary