Selecting & Prioritizing Pipeline Replacements Using Pipeline Risk Model

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EBMUD Pipeline Inventory

- Serves 1.4 million customers in over 20 cities
- 4,200 miles of Pipeline
  - 400 mi Transmission Pipe (>20”)
  - 3,800 mi Distribution Pipe (≤ 20”)
  ~25% in Fault Zone or Landslide Zone
- Average Age of Pipe = 57 years
- Oldest Pipe = 142 years
Leaks & Pipeline Replacement Program

- Average 989 leaks/year
- Replacing 15 miles/year with 10 District Crews

How do we make sure we are replacing the **right** pipe?
Pipeline Risk Model

RISK = (Likelihood of Failure) x (Consequence of Failure)

“LOF”
The probability a pipeline will leak.

“COF”
The resulting magnitude of consequence if the pipe does leak.
Risk Matrix & Model Results

Many published industry reports have concluded that leak history is the greatest indicator of future leaks.

If all else is equal, better to replace older pipe to get better life cycle costs.

**LOF Scoring:**

90% based on Leak History

10% based on Pipe Age

\[
LOF \text{ Score } = \sum_{i}^{n} [(LOF \text{ Weight})_i \times (LOF \text{ Rank})_i]
\]

x-y coordinates = Leak Address

Leak ‘Pipeline ID’ = ‘Pipeline ID’ within 200-foot radius
## Likelihood of Failure Scores

<table>
<thead>
<tr>
<th>Score</th>
<th>% of Network</th>
<th>Simplified Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOF 1</td>
<td>69%</td>
<td>New pipe or old pipe that has never leaked (<em>53% is over 50 years old</em>)</td>
</tr>
<tr>
<td>LOF 2</td>
<td>15%</td>
<td>Pipe that has leaked once</td>
</tr>
<tr>
<td>LOF 3</td>
<td>7%</td>
<td>Pipe that has leaked 2-3 times</td>
</tr>
<tr>
<td>LOF 4</td>
<td>7%</td>
<td>Pipe that has leaked &gt;3 leaks/1,000 feet (<em>old cost benefit ratio calculation</em>)</td>
</tr>
<tr>
<td>LOF 5</td>
<td>2%</td>
<td>The leakiest 2% of distribution system</td>
</tr>
</tbody>
</table>
## Consequence of Failure

### Diameter

- Consumption
- Critical Customers
- Ease of Access
- Creek Crossing
- Highway Crossing
- Railroad Crossing
- Major Road Crossing
## Consequence of Failure

<table>
<thead>
<tr>
<th>Risk Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter</td>
</tr>
<tr>
<td>Consumption</td>
</tr>
<tr>
<td>Critical Customers</td>
</tr>
<tr>
<td><strong>Ease of Access</strong></td>
</tr>
<tr>
<td><strong>Creek Crossing</strong></td>
</tr>
<tr>
<td>Highway Crossing</td>
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</tr>
</tbody>
</table>

![Image of workers in a forested area with equipment]
Consequence of Failure

- Diameter
- Consumption
- Critical Customers
- Ease of Access
- Creek Crossing
- Highway Crossing
- Railroad Crossing
- Major Road Crossing
Risk Matrix & Model Results

Likelihood of Failure Scores

<table>
<thead>
<tr>
<th>Consequence of Failure Scores</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>F</td>
</tr>
<tr>
<td></td>
<td>(1,449 mi)</td>
<td>(275 mi)</td>
<td>(163 mi)</td>
<td>(168 mi)</td>
<td>(53 mi)</td>
</tr>
<tr>
<td>2</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>F</td>
</tr>
<tr>
<td></td>
<td>(500 mi)</td>
<td>(111 mi)</td>
<td>(49 mi)</td>
<td>(42 mi)</td>
<td>(13 mi)</td>
</tr>
<tr>
<td>3</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>F</td>
</tr>
<tr>
<td></td>
<td>(299 mi)</td>
<td>(89 mi)</td>
<td>(35 mi)</td>
<td>(24 mi)</td>
<td>(10 miles)</td>
</tr>
<tr>
<td>4</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>F</td>
<td>F</td>
</tr>
<tr>
<td></td>
<td>(185 mi)</td>
<td>(64 mi)</td>
<td>(14 mi)</td>
<td>(10 mi)</td>
<td>(2 mi)</td>
</tr>
<tr>
<td>5</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>F</td>
<td>F</td>
</tr>
<tr>
<td></td>
<td>(190 mi)</td>
<td>(44 mi)</td>
<td>(9 mi)</td>
<td>(6 mi)</td>
<td>(2 mi)</td>
</tr>
</tbody>
</table>

Risk Grades

- **A Pipe**: 59% 2,248 mi
- **B Pipe**: 22% 850 mi
- **C Pipe**: 9% 355 mi
- **D Pipe**: 7% 264 mi
- **F Pipe**: 3% 96 mi

View Results Geographically on ArcGIS Online

Focus on these pipes
Selecting Projects in ArcGIS Online
Model Verification

- **LOF 5** pipe is 23x more likely to leak than an **LOF 1** pipe.
- ~1/2 the leaks occur on **LOF 4** & **LOF 5** pipelines (9% of network).
- Can estimate pipe life expectancy:

![Diagram with letters A to F and corresponding distances and probabilities]
Benefits of Using Risk Model

- Automates assessment of all 3,800 miles of distribution pipe
- Identifies “right” pipes for replacement
- Provides transparency on replacement decisions
- Provides ability to forecast leak rates & replacement rate needs

What will leak rate be in $X$ years if we replace $X$ miles of $F$ pipe per year?
Questions?