Project Prioritization (Optimization)

Water Research Foundation's Intelligent Water Networks Summit

Alexandria, VA

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MSD’s Background and History

- Created in 1946 to provide wastewater service to Jefferson County, Kentucky
- Assumed responsibility for most of the stormwater and drainage of Jefferson County in 1987
- Took over flood protection from US Army Corps of Engineers (USACE) in 1987
- Operating budget $125 million/year (FY18) and 625 employees

Five regional WQTCs
- 600 miles of combined sewers
- 2,700 miles of separate sewers
- 260+ pump stations
- 1,400 miles of laterals
MSD’s Recent Focus

- In 2005 MSD entered into a Federal Consent Decree to control CSOs and SSOs by 2020 and 2024, respectively
- 98% wet weather capture and treatment
- Estimated cost = $930 million (more than $400 million invested)
- Focus of utility shifted to overflow control program

Capital Spending Trends

- RTC
- Ohio River Flood Protection
- Support Systems
- Consent Decree
- Wastewater
- Stormwater

IOAP implementation begins
Planning Approach

• Consent Decree projects were well documented, prioritized, with regulatory imperative (overflow control only)
• Other areas did not have same urgency or consistent planning approach
• Proactively addressing community needs
• Need for development of a comprehensive prioritization approach across all service areas
• Team tasked with determining what was needed, not what fits current funding limits
Prioritization

• Some projects are only effective if they are initiated at specific times

• Top priority projects:
  – Regulatory requirement
  – Equipment replacement
  – Annual allocation
  – Asset maintenance
  – Expansion to meet population projections
  – Deliver lowest life-cycle costs (facility, floodwall, and levee projects)

How do you balance the needs across so many compelling yet competing interests?
Decision Process Beyond Traditional Benefit/Cost Analysis

- Followed WEF Guide to Managing Peak Wet Weather Flows
  - Common timing of manual release by WEF
  - Common technical consultant
  - First city to implement entire process
- Risk management-based decision process
- Community values were basis for benefit metrics
- Science-driven process and outcome
• Risk management approach considers
  • Overflow frequency
  • Consequence of overflow

• Reducing frequency or consequence of overflow results in quantifiable benefit

Risk = Frequency x Consequence
Prioritization Tool Needs & Objectives

- Leverage work that has been successful
- Approach must be:
  - Defensible
  - Repeatable
  - Accountable
- Make decisions based on the information we have
  - Data driven approach
  - Adapting to when projects begin
  - Adapting for different financial scenarios
- Each project has multiple characteristics to be evaluated simultaneously
  - Across all service areas
  - Recommend sequencing of projects
  - Display geographical distribution
Prioritization Process Development to Date

October
- Initial concept & scope development

November
- Tool development
  - Monetized risk approach

December - January
- Testing & refinement

January - February
- Use in parallel with existing budgeting cycle

Benefits to MSD for utilizing Optimizer platform:
- Unique tool, built for specific needs
- Uses standard, established interface
- Cloud computing & metaheuristic optimization
Defining What is Available for Optimization

Without these numbers, the tool will not function properly

This differential is the budget that OPTIMIZER will be used to prioritize projects to

IOAP + Annual Allocations

Annual Allocations

2016 2018 2020 2022 2024 2026 2028 2030 2032 2034 2036 2038

Non Priorized Projects Total Budget
Base Data
- Overall Budget
- Budget for Prioritized projects
- Geographical Info.

Inputs
- Project Details
- Location
- Monetized Risk
- Benefit
- Cost (per year)

Outputs
- Project List (per year)
- Project Details
- Location
Monetized Risk

- Based on EPA SIMPLE approach
- The CoF is an actuarial value and does not reflect the precise cost of a particular event
- It is solely an estimate to add a meaningful metric to relative risks
- Consistency is more important than accuracy when comparing large numbers of disparate assets
# Proposed Consequence of Failure Criteria

<table>
<thead>
<tr>
<th>Impact</th>
<th>Description</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Environmental</strong></td>
<td></td>
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<tr>
<td>Regulatory Violations</td>
<td>Overflows (discharge to waters of the US) Permit Violations at WWTP USACE Violations MS4 Violations</td>
<td>Short duration, low quantity, contained within facility</td>
<td>Minor disruption, few complaints, short process upset, minor SSO less than 1000 gals. ($ based on local regulatory fines)</td>
<td>Substantial disruption, numerous complaints, prolonged process recovery, significant SSO</td>
<td>Major disruption, complete loss of process, major SSO, 0-6 month recovery time.</td>
<td>Major disruption, complete loss of process, spill of &gt;100,000 gallons, &gt; 6 month recovery time.</td>
</tr>
<tr>
<td>Monetized Value</td>
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<td>$</td>
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</tr>
<tr>
<td>Environmental Impact</td>
<td>Fauna, flora, water quality, odor, other miscellaneous factors</td>
<td>Low quantity, short duration</td>
<td>Few complaints, minor SSO less than 1000 gals.</td>
<td>Substantial disruption, numerous complaints, significant SSO, prolonged environmental recovery</td>
<td>Major disruption, widespread ratepayer complaints, major SSO, 0-6 month recovery time</td>
<td>Major disruption, widespread regional complaints, spill of &gt;100,000 gallons, &gt; 6 month recovery time.</td>
</tr>
<tr>
<td>Monetized Value</td>
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<tr>
<td><strong>Social</strong></td>
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<tr>
<td>Health &amp; Safety</td>
<td>Public health and safety impacts, employee safety, regulatory compliance.</td>
<td>First aid required (cut, bruise, topical rash)</td>
<td>Minor injury (Sprain, stitches)</td>
<td>Severe injury or illness with permanent damage</td>
<td>Single fatality (EPA death avoidance cost @ $9M), localized illness</td>
<td></td>
</tr>
<tr>
<td>Monetized Value</td>
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<td>$$$</td>
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<td>$$$</td>
</tr>
<tr>
<td>Level of Service</td>
<td>Reduced fire flow, poor water quality, impaired treatment ability, dimished system capacity</td>
<td>Short duration disruption, less than 100 customers affected</td>
<td>Up to 1,000 customers affected.</td>
<td>Up to 10,000 customers affected.</td>
<td>Up to 100,000 customers affected.</td>
<td>More than 100,000 customers affected.</td>
</tr>
<tr>
<td>Monetized Value</td>
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<td>$</td>
<td>$</td>
<td>$$$</td>
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</tr>
<tr>
<td>Public Image</td>
<td>Media coverage based on number of people affected, environmental impacts, financial loss, lawsuits</td>
<td>Limited complaints (neighborhood level)</td>
<td>Local adverse media (County level)</td>
<td>Broad adverse media, (Service area and neighboring jurisdictions)</td>
<td>Regional adverse media, (State level), political consequences</td>
<td>National adverse media, political and regulatory consequences</td>
</tr>
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<td>Monetized Value</td>
<td>$</td>
<td>$</td>
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<tr>
<td><strong>Economic</strong></td>
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<tr>
<td>Direct Cost (External)</td>
<td>Lost revenue, total repair costs, liability costs, fines, properly damage.</td>
<td>&lt;$100K</td>
<td>$100K-$1M</td>
<td>$1M-$5M</td>
<td>$5-$15M</td>
<td>&gt;$15M</td>
</tr>
<tr>
<td>Monetized Value</td>
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</tr>
<tr>
<td>Indirect Cost (Internal)</td>
<td>Organizational operating costs including additional personnel cost, insurance rate increases, reduced operational efficiency (increased chemical cost/containment requirements/ regulatory costs)</td>
<td>Moderate operational changes, 2% - 3% increase in operating costs</td>
<td>Moderate operational changes and process costs, 3% - 5% increase in operating costs</td>
<td>Significant operational costs, 5% - 10%, increase in operating costs. Impacts other activities.</td>
<td>Major operational costs, 10% - 25%, increase in operating costs. Impacts other activities.</td>
<td>Major operational costs, &gt;25% increase in operating costs. Rate and organizational change impacts</td>
</tr>
<tr>
<td>Monetized Value</td>
<td>$</td>
<td>$</td>
<td>$</td>
<td>$$$</td>
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</tbody>
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Probability of Failure

• How to account for:
  – Existing assets that are old(er) but in very good condition?
  – Existing assets that are new but in very poor condition?

SCALING FACTORS

% of Design Life Remaining \times \frac{\% of Design Capacity Met}{\text{Condition}} = \text{Probability of Failure (PoF)}

Assets consistently overwhelmed have increased likelihood of premature failure
Mitigation Factors

- Similar in concept to a safety factor, may:
  - Offset the impact of a failure (CoF)
  - Reduce the overall risk (PoF)

<table>
<thead>
<tr>
<th>Redundancy Level</th>
<th>Mitigation Factor</th>
<th>Description</th>
<th>Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Backup</td>
<td>1.00</td>
<td>All capacity lost</td>
<td>N/A</td>
</tr>
<tr>
<td>10% Backup</td>
<td>0.90</td>
<td>10% of capacity available after failure of an asset</td>
<td>CoF Reduction</td>
</tr>
<tr>
<td>20% Backup</td>
<td>0.80</td>
<td>Emergency response plan; mobile back online</td>
<td>CoF Reduction</td>
</tr>
<tr>
<td>25% Backup</td>
<td>0.75</td>
<td>Bypass/diversion; real time monitoring, critical spares on site</td>
<td>PoF Reduction</td>
</tr>
<tr>
<td>30% Backup</td>
<td>0.70</td>
<td>30% of capacity available after failure of an asset</td>
<td>CoF Reduction</td>
</tr>
<tr>
<td>35% Backup</td>
<td>0.65</td>
<td>Containment of impact, i.e. spills, overflows</td>
<td>CoF Reduction</td>
</tr>
<tr>
<td>40% Backup</td>
<td>0.60</td>
<td>40% of capacity available after failure of an asset</td>
<td>CoF Reduction</td>
</tr>
<tr>
<td>50% Backup</td>
<td>0.50</td>
<td>Can be operated manually; limited functional operation; shelf spares</td>
<td>PoF Reduction</td>
</tr>
<tr>
<td>75%-80% Backup</td>
<td>0.20</td>
<td>75%-80% of capacity available after failure of an asset</td>
<td>CoF Reduction</td>
</tr>
<tr>
<td>100% Backup</td>
<td>0.10</td>
<td>One complete redundant system</td>
<td>CoF Reduction</td>
</tr>
<tr>
<td>200% Backup</td>
<td>0.02</td>
<td>Two complete redundant systems</td>
<td>CoF Reduction</td>
</tr>
<tr>
<td>&gt;200% Backup</td>
<td>0.01</td>
<td>More than two complete redundant systems</td>
<td>CoF Reduction</td>
</tr>
</tbody>
</table>
## Community Values (Benefits)

<table>
<thead>
<tr>
<th>Project-Specific Values</th>
<th>Aspects</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Environmental Impacts</strong></td>
<td>Terrestrial habitat, aquatic habitat, tree canopy, visual aesthetics, odor aesthetics, stream base flow, stream peak flow, nutrient loadings, impaired use impacts</td>
</tr>
<tr>
<td><strong>Regulatory Compliance</strong></td>
<td>Kentucky Pollutant Discharge Elimination System (KPDES), MS4, ACD, flood plain management, air pollution control permits, biosolids</td>
</tr>
<tr>
<td><strong>Public Health Protection</strong></td>
<td>Pathogen exposure, drowning risk, mold exposure</td>
</tr>
<tr>
<td><strong>Property Protection</strong></td>
<td>Basement backup, surface flooding – traffic disruption, surface flooding – structural damage, flood insurance rating, public utility delivery</td>
</tr>
<tr>
<td><strong>Sustainability</strong></td>
<td>Non-renewable resource consumption, mechanical vs. natural systems, multipurpose community asset, public access, public information/education enabler, reclaim abandoned or under-utilized land, impact on impervious surface, land use compatibility or improvement</td>
</tr>
<tr>
<td><strong>Economic Vitality</strong></td>
<td>Number of residential customers, flow/load from commercial/industrial</td>
</tr>
</tbody>
</table>
Cost Estimating

- Most capital costs estimated using the same approach and tool as IOAP costs
- Others were based on structures or unit processes (i.e. WQTCs) and/or bid tabs
- Whenever possible, costs from reports or studies were used with updated dollars
Reporting
What’s Next for MSD

- Outline non-prioritized projects
- Perform the draft prioritization for FY19
  - Parallel to traditional methods
- Run optimization for projects that provide the greatest risk reduction or highest benefit
  - Allows us to validate the scoring criteria
  - May generate additional refinements
- Define output/reporting wants and needs
- Gain acceptance … build trust