Risk Management on Infrastructure Tunnel Projects
Matt Koziol, PE
Learning Objectives

1. An appreciation for the size and complexity of the DC Clean Rivers Project
2. A cursory understanding of risk management theory and processes
3. Results of the Risk Management process for DCCRP
DC Clean Rivers Project (DCCRP)

In 2005, DC Water entered into a consent decree with the Department of Justice, the EPA, and the District of Columbia and embarked on what is currently a 25-year (2005-2030), $2.77 billion program christened the DC Clean Rivers Project to reduce CSOs into the Anacostia River, the Potomac River, and Rock Creek by 96% during an average year.
DC Clean Rivers
Overview Current Plan
What is a CSO?

On average, 2.1 billion gallons of untreated sewage and stormwater runoff (combined sewage) are discharged to the Anacostia River per year.
DCCRP Project Solution for the Anacostia River
Anacostia River Tunnel System Snapshot

More than $1.3 B in Contracts have been let for the Anacostia River Projects
## Anacostia River Tunnel System Snapshot

<table>
<thead>
<tr>
<th>Project</th>
<th>Diameter</th>
<th>Length</th>
<th>Start</th>
<th>Finish</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blue Plains Tunnel</td>
<td>23</td>
<td>24,207</td>
<td>5/2011</td>
<td>12/2015</td>
</tr>
<tr>
<td>Anacostia River Tunnel</td>
<td>23</td>
<td>12,484</td>
<td>6/2013</td>
<td>12/2017</td>
</tr>
<tr>
<td>Northeast Boundary Tunnel</td>
<td>23</td>
<td>27,000</td>
<td>9/2017</td>
<td>5/2023</td>
</tr>
<tr>
<td>First Street Tunnel</td>
<td>20</td>
<td>2,700</td>
<td>10/2013</td>
<td>10/2016</td>
</tr>
</tbody>
</table>

**Combined total length of 12.6 miles**
# DCCR Projects Contract Delivery Methods / Status

A total of 17 separate Divisions completed or under design/construction:

<table>
<thead>
<tr>
<th>Div</th>
<th>Description</th>
<th>Cost (M)</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Blue Plains Tunnel</td>
<td></td>
<td>Complete</td>
</tr>
<tr>
<td>H</td>
<td>Anacostia River Tunnel</td>
<td></td>
<td>Construction</td>
</tr>
<tr>
<td>P</td>
<td>First Street Tunnel</td>
<td></td>
<td>Construction</td>
</tr>
<tr>
<td>I</td>
<td>Main Pumping Station Divisions</td>
<td></td>
<td>Construction</td>
</tr>
<tr>
<td>D</td>
<td>JBAB Outfall and Diversion Structures</td>
<td></td>
<td>Construction</td>
</tr>
<tr>
<td>J</td>
<td>Northeast Boundary Tunnel</td>
<td></td>
<td>Procurement</td>
</tr>
<tr>
<td>PR-A</td>
<td>Potomac Area Green Infrastructure</td>
<td></td>
<td>TBD Design/Proc</td>
</tr>
<tr>
<td>RC-A</td>
<td>Rock Creek Area Green Infrastructure</td>
<td></td>
<td>TBD Design/Proc</td>
</tr>
<tr>
<td>B</td>
<td>Tingey Street Diversion Sewer</td>
<td></td>
<td>Complete</td>
</tr>
<tr>
<td>PR-B</td>
<td>CSO 021 Diversion Facilities</td>
<td></td>
<td>Construction</td>
</tr>
<tr>
<td>W</td>
<td>Blue Plains Demolition</td>
<td></td>
<td>Complete</td>
</tr>
<tr>
<td>C</td>
<td>CSO 019 Outfall and Diversion Structures</td>
<td></td>
<td>Complete</td>
</tr>
<tr>
<td>G</td>
<td>CSO 007 Diversion Sewer</td>
<td></td>
<td>Complete</td>
</tr>
<tr>
<td>E</td>
<td>M Street Diversion Sewer</td>
<td></td>
<td>Construction</td>
</tr>
<tr>
<td>Z</td>
<td>Poplar Point Pumping Station Replacement</td>
<td>$53</td>
<td></td>
</tr>
<tr>
<td>U</td>
<td>NEBT Utility Relocations</td>
<td>$17</td>
<td>Complete</td>
</tr>
</tbody>
</table>
Introduction to Risk Management
Our Risk Management Approach

Risk Management = Identification + Evaluation + Mitigation
A risk is an uncertain event or condition that, if it occurs, has a positive or negative effect on one or more project objectives\(^1\).

\(^1\) Project Management Institute (PMI) - A Guide to the Project Management Body of Knowledge (PMBOK Guide)
Identification

Brainstorm

- Lessons Learned
- Assumptions
- Constraints
- Threats
- Opportunities
- Scope
- Categorization
## Identification

### Risk Breakdown Structure

<table>
<thead>
<tr>
<th>Category</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning</td>
<td>100</td>
<td>General Planning</td>
</tr>
<tr>
<td></td>
<td>200</td>
<td>ROW &amp; Easements</td>
</tr>
<tr>
<td></td>
<td>300</td>
<td>Permits</td>
</tr>
<tr>
<td></td>
<td>400</td>
<td>Public Relations/Acceptance</td>
</tr>
<tr>
<td></td>
<td>500</td>
<td>Legal Funding</td>
</tr>
<tr>
<td>Design</td>
<td>600</td>
<td>Engineering</td>
</tr>
<tr>
<td>Procurement</td>
<td>700</td>
<td>Contracting Issues</td>
</tr>
<tr>
<td>Construction</td>
<td>800</td>
<td>Material, Equipment &amp; Labor Supply</td>
</tr>
<tr>
<td></td>
<td>900</td>
<td>Environment/Public Impacts</td>
</tr>
<tr>
<td></td>
<td>1000</td>
<td>General Site Conditions</td>
</tr>
<tr>
<td></td>
<td>1100</td>
<td>Construction</td>
</tr>
<tr>
<td></td>
<td>1200</td>
<td>Material Installation</td>
</tr>
<tr>
<td></td>
<td>1300</td>
<td>Safety &amp; Security</td>
</tr>
<tr>
<td>Operations</td>
<td>1400</td>
<td>System Operations</td>
</tr>
</tbody>
</table>
**Evaluation**

In a collaborative workshop the risks are qualitatively rated by evaluating or assessing and combining each risk’s relative likelihood of occurrence and severity of consequence on a scale of 1-5 to determine a risk rating for each risk.

**Risk Rating = L x S**
Mitigation

Utilizing the risk ratings as a prioritization tool, mitigation actions are developed and assigned to a responsible party or person.
# Mitigation: Risk Register

<table>
<thead>
<tr>
<th>Risk ID</th>
<th>Project Plan</th>
<th>Risk</th>
<th>Priority</th>
<th>Impact</th>
<th>Risk ID</th>
<th>Project Plan</th>
<th>Risk</th>
<th>Priority</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>PROJECT PLANNING &amp; DEVELOPMENT</td>
<td>101</td>
<td>Failure to adequately size str</td>
<td>5 - Schedule</td>
<td>4</td>
<td>3</td>
<td>12</td>
<td>1. Research State requirements.</td>
<td>1. Designer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.</td>
<td>sufficient size str construc</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2. Determine theoretical drawn-down levels.</td>
<td>2. Designer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.</td>
<td>tion.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3.</td>
<td>1. Owner/Designer</td>
</tr>
<tr>
<td>200</td>
<td>PROJECT PLANNING &amp; DEVELOPMENT</td>
<td>201</td>
<td>Unable to obtain permits</td>
<td>5 - Schedule</td>
<td>4</td>
<td>2</td>
<td>8</td>
<td>1. Research power needs and availability.</td>
<td>1. Designer</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td>2. Develop list of permits.</td>
<td>2. Designer</td>
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<td></td>
<td></td>
<td>3. Conduct a permit preapplication meeting.</td>
<td>3. Designer</td>
</tr>
<tr>
<td>300</td>
<td>PROJECT PLANNING &amp; DEVELOPMENT</td>
<td>301</td>
<td>Difficulty in obtaining or maintaining</td>
<td>5 - Schedule</td>
<td>4</td>
<td>3</td>
<td>12</td>
<td>1. Research State requirements.</td>
<td>1. Designer</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>permit for dewatering.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2. Determine theoretical drawn-down levels.</td>
<td>2. Designer</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3.</td>
<td>1. Owner/Designer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>302</td>
<td>An unknown permit is required (e.g. air quality)</td>
<td>5 - Schedule</td>
<td>4</td>
<td>2</td>
<td>8</td>
<td>1. Research power needs and availability.</td>
<td>1. Owner/Designer</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2. Develop list of permits.</td>
<td>2. Designer</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3. Conduct a permit preapplication meeting.</td>
<td>3. Designer</td>
</tr>
<tr>
<td>400</td>
<td>PROJECT PLANNING &amp; DEVELOPMENT</td>
<td>401</td>
<td>Local public opposition to read</td>
<td>C - Cost</td>
<td>5</td>
<td>3</td>
<td>15</td>
<td>1. Educate community about project</td>
<td>1. Owner</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>closures/traffic issues</td>
<td>G - Other</td>
<td></td>
<td></td>
<td></td>
<td>2. Identify construction haul and access routes.</td>
<td>2. Owner/Designer</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>associated with construction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3. Identify alternate routes and detours.</td>
<td>3. Designer</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4. Completed</td>
<td>1. Ongoing</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5. Future</td>
<td>2. Ongoing</td>
</tr>
</tbody>
</table>
Quantitative Cost Analysis

In a collaborative workshop we quantify each cost impact risk by assigning a probability of occurrence and a range of cost consequences in dollars.

\[ \text{Cost Impacts} = P \times C \times O \]

<table>
<thead>
<tr>
<th>Risk ID</th>
<th>Risk Description</th>
<th>Probability of Occurrence %</th>
<th>Owners Share of Risk %</th>
<th>Multiple Occurrence Possible?</th>
<th>Consequence in $</th>
</tr>
</thead>
<tbody>
<tr>
<td>900</td>
<td><strong>CONSTRUCTION - Environmental/Public Impacts (permit non-compliance)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>903</td>
<td>Contaminated groundwater drawn into excavations resulting in extra cost, time and third party claims</td>
<td>5%</td>
<td>100%</td>
<td>Y</td>
<td>$250k $300k $500k $700k $750k</td>
</tr>
<tr>
<td>904</td>
<td>Contractor encounters cultural or archaeological resources (or potentially cultural or archaeological resources) during construction</td>
<td>90%</td>
<td>100%</td>
<td>Y</td>
<td>$25K $100K $250K $300K $750K</td>
</tr>
<tr>
<td>908</td>
<td>Contractor unable to cut off water from excavations due to multiple SOE systems is used</td>
<td>50%</td>
<td>100%</td>
<td>Y</td>
<td>$0k $50k $500k $700k $2500k</td>
</tr>
<tr>
<td>1000</td>
<td><strong>CONSTRUCTION - General Site Conditions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1001b</td>
<td>Construction fails to complete TBM removal in their 90-day window</td>
<td>50%</td>
<td>100%</td>
<td>N</td>
<td>$100k $200k $400k $750k $1000k</td>
</tr>
</tbody>
</table>
Quantitative Cost Analysis

We are 95% confident that the total cost impact from risks will be $8.96M or less from today through the duration of this project.
## Quantitative Schedule Analysis

<table>
<thead>
<tr>
<th>Risk ID</th>
<th>Risk Description</th>
<th>Schedule Activity</th>
<th>Probability of Occurrence %</th>
<th>Consequence in Days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Minimum</td>
</tr>
<tr>
<td>1100</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1103</td>
<td>Tunneling induced settlement of CSX railroad, exceeds allowable limits</td>
<td>TBM-CON-1120</td>
<td>2%</td>
<td>5</td>
</tr>
<tr>
<td>1107</td>
<td>Existing sewers or utilities are damaged due to age or condition</td>
<td>CON-VS-1570, CON-VS-1240</td>
<td>20%</td>
<td>3</td>
</tr>
</tbody>
</table>

The variability of schedule activities are also assigned:

<table>
<thead>
<tr>
<th>Activity ID</th>
<th>Activity</th>
<th>Activity Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Minimum</td>
</tr>
<tr>
<td>TBM-CON-1120</td>
<td>TBM mine from Station 0+00 to 12+43</td>
<td>20</td>
</tr>
<tr>
<td>CON-VS-1570</td>
<td>Tie-in to existing 36” RCCP water main</td>
<td>3</td>
</tr>
</tbody>
</table>
We are 80% confident that, considering the impacts of risks and the estimated variability in selected activity durations, the project will finish on 09-02-16 or earlier.
Results of Risk Management Process for DCCRP

- Risk Aware Culture
- Tools for PM’s and CM’s
- Scope Transfer for Efficiency
- Informed Budget Decisions
- Allocation of Engineering Resources
Thank You

Matt Koziol, PE
Project Engineer

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