Levee Ready Columbia (LRC) Risk Informed Decision Making Process
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Risk Informed Decision Making Process

Presented by:

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Water Resource Planner
Introduction

- Four drainage districts
- 27 miles of levees
- 10% of jobs in Multnomah County
- Portland International Airport (PDX)
- Oregon’s second largest source of drinking water

- Over 15 separate stakeholder entities
- 2 cities (Portland and Troutdale)
Problem:
• How to define and assess risk among various projects, and project partners, with differing amounts of available technical data. Plus, compare trade-offs when assessing alternative projects

Solution:
• Develop an Excel based, non-proprietary, Risk Informed Decision-Making (RIDM) tool that would:
  ▪ Provide a framework to input quantitative and qualitative data
  ▪ Compare an array of projects
Process Overview

1. Define Risk
2. Develop metrics for use in tool
3. Assess relative weighting of metrics
4. Finalize Framework
5. Compile data for use in tool
6. Develop alternative projects
7. Run tool and analyze potential projects
1. Define Risk

• What is Risk
  ▪ Various definitions:
    – FEMA
    – USACE
    – Bureau of Reclamation
    – Others....

• Basic definition:
  ▪ A measure of the probability and consequence of uncertain future events.

Risk = Probability x Consequence
1. Define Risk

For purposes of this project calculation of risk followed USACE levee risk which incorporates:

https://www.usace.army.mil/Missions/Civil-Works/Levee-Safety-Program/Risk-Assessment/
1. Define Risk

Hazard

- Flooding
1. Define Risk

Performance:

- Probability of failure given a high flow event (flood)
- Ability of levee to hold during 100-yr and 500-yr events
1. Define Risk

Consequences

**Jobs & Economy**
- $16 billion economic activity annually
- 50% Region’s manufacturing & warehouse jobs
- 18.4 million passengers annually at PDX
- 3 interstates
- 2 highways
- 2 railroads
- 2 airports
- $7.3 billion property value

**Drinking Water**
- #2 largest source of drinking water in Oregon
- #1- Bull Run Reservoir

**Nature & Habitat**
- Western Painted Turtle
- Western Pond Turtle
- Beaver
- Nutria
- Carp and Bass
- 175 species
- Birds in the watershed

**Recreation & Culture**
- Over 2,000 acres
- Parks, open spaces, and recreational areas
- 17 miles Marine Drive multi-use path
- 7,500 residents served
- 15 miles Water trails for canoes and kayaks
2. Metric Development

• An item that is able to be input into the analysis either with qualitative or quantitative inputs.
  - Developed metrics to fit into the three categories of risk (hazard, performance and consequences)

<table>
<thead>
<tr>
<th>HAZARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Riverine Flooding:</td>
</tr>
<tr>
<td>1% annual-chance exceedance (100-year)</td>
</tr>
<tr>
<td>0.2% annual-chance exceedance (500-year)</td>
</tr>
<tr>
<td>Flooding from Pump Station Failure</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PERFORMANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Levee Performance</td>
</tr>
<tr>
<td>Levee Failure Modes / Fragility Curves:</td>
</tr>
<tr>
<td>Seepage (Fragility Curve)</td>
</tr>
<tr>
<td>Stability (Fragility Curve)</td>
</tr>
<tr>
<td>Scour</td>
</tr>
<tr>
<td>Settlement</td>
</tr>
<tr>
<td>Freeboard</td>
</tr>
<tr>
<td>Design Criteria</td>
</tr>
<tr>
<td>Operations Failure</td>
</tr>
<tr>
<td>Inadequate Maintenance</td>
</tr>
<tr>
<td>Encroachments</td>
</tr>
<tr>
<td>Emergency Preparedness / System Redundancy</td>
</tr>
<tr>
<td>Seismic</td>
</tr>
<tr>
<td>Natural System Resiliency / Adaptability</td>
</tr>
<tr>
<td>Pump Station Performance</td>
</tr>
<tr>
<td>Inspection Checklist</td>
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</tbody>
</table>
# 2. Metrics

## CONSEQUENCES

<table>
<thead>
<tr>
<th>Category</th>
<th>Subcategories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population and Structures:</td>
<td>Number of Structures by Type, Essential / Critical Facilities, Community Assets / Social Consequences, Population Impacted, Environmental Justice &amp; Equity, Health/ Illness</td>
</tr>
<tr>
<td>Jobs and Economy:</td>
<td>Structure Damages, Business Losses / Disruption, Freight / Transportation Disruptions, Airport Impacts (Local/Regional), Income and Wages Lost, Insurance-related Costs, Lost Revenue, Emergency Repair Costs, Debris Disposal</td>
</tr>
<tr>
<td>Nature and Habitat:</td>
<td>Ecosystem/ Habitat Impacts, Landscaped Area Impacts, Fish Habitat Impacts, Species Impacts</td>
</tr>
<tr>
<td>Recreation and Culture:</td>
<td>Parks / Recreation Area Impacts, Multi-use Path Impacts, Utility &amp; Telecommunications Disruptions, Water Quality</td>
</tr>
</tbody>
</table>

## PRIORITIZATION

<table>
<thead>
<tr>
<th>Category</th>
<th>Subcategories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Construction / Implementation Costs</td>
<td>Annual O&amp;M Costs, NEPA/Environmental Permitting Costs/Delays</td>
</tr>
<tr>
<td>Project Benefits Factors:</td>
<td>Environmental Benefits, Social Equity Benefits, Recreation Benefits</td>
</tr>
</tbody>
</table>
3. Assess Relative Weighting

• Used to assess the risk tolerances (or conversely, risk aversion preferences) of the LRC stakeholders.

• Multiple working group meetings in addition to “surveys” for group members to assess risk
3. Assess Relative Weighting

<table>
<thead>
<tr>
<th>Grouping</th>
<th>Consequence Metric</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>Population Impacted</td>
<td>15.0</td>
</tr>
<tr>
<td>Group 1</td>
<td>Essential / Critical Facility Locations</td>
<td>12.5</td>
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<tr>
<td>Group 1</td>
<td>Health / Safety Facilities</td>
<td>7.5</td>
</tr>
<tr>
<td>Group 1</td>
<td>PDX Airport Impacts (Local/Regional)</td>
<td>7.5</td>
</tr>
<tr>
<td>Group 2</td>
<td>Number of Structures by Type</td>
<td>5.5</td>
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<tr>
<td>Group 2</td>
<td>Groundwater Wells Inundated</td>
<td>5.5</td>
</tr>
<tr>
<td>Group 2</td>
<td>Environmental Justice &amp; Equity</td>
<td>5.0</td>
</tr>
<tr>
<td>Group 2</td>
<td>Public Lifeline Utilities</td>
<td>5.0</td>
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<tr>
<td>Group 2</td>
<td>Structure Damages</td>
<td>4.5</td>
</tr>
<tr>
<td>Group 2</td>
<td>Hazardous Material Sites Inundated</td>
<td>4.0</td>
</tr>
<tr>
<td>Group 3</td>
<td>Business Losses / Disruption</td>
<td>3.5</td>
</tr>
<tr>
<td>Group 3</td>
<td>Income and Wages Lost</td>
<td>3.0</td>
</tr>
<tr>
<td>Group 3</td>
<td>Freight / Transportation Disruptions</td>
<td>3.0</td>
</tr>
<tr>
<td>Group 3</td>
<td>Telecommunication Lines Impacted</td>
<td>2.5</td>
</tr>
<tr>
<td>Group 3</td>
<td>Emergency Repair Costs</td>
<td>2.5</td>
</tr>
<tr>
<td>Group 4</td>
<td>Fish Habitat Impacts</td>
<td>2.0</td>
</tr>
<tr>
<td>Group 4</td>
<td>Community Assets / Social Consequences</td>
<td>2.0</td>
</tr>
<tr>
<td>Group 4</td>
<td>Ecosystem / Habitat Impacts</td>
<td>2.0</td>
</tr>
<tr>
<td>Group 4</td>
<td>Species Impacts</td>
<td>1.5</td>
</tr>
<tr>
<td>Group 4</td>
<td>Debris Disposal</td>
<td>1.5</td>
</tr>
<tr>
<td>Group 4</td>
<td>Lost Revenue</td>
<td>1.5</td>
</tr>
<tr>
<td>Group 4</td>
<td>Insurance-related Costs</td>
<td>1.5</td>
</tr>
<tr>
<td>Group 5</td>
<td>Parks / Recreation Area Impacts</td>
<td>0.5</td>
</tr>
<tr>
<td>Group 5</td>
<td>Landscaped Area Impacts</td>
<td>0.5</td>
</tr>
<tr>
<td>Group 5</td>
<td>Multi-use Path Impacts</td>
<td>0.5</td>
</tr>
</tbody>
</table>
4. Framework

1. **EXISTING RISK ASSESSMENT**
   - **HAZARD**
     - Simplified Annual Probability of Event (AP)
   - **PERFORMANCE**
     - Failure Probability (FP)
   - **CONSEQUENCES**
     - Combined Consequence Risk Value (CCR)

   \[
   \text{AP} \times \text{FP} \times \text{CCR} = \text{Overall Risk Value}
   \]

   \[
   \%
   \text{Max. Value} = 100
   \]

2. **PROJECT PRIORITIZATION**
   - **Estimated Risk Reduction**
     - Overall Risk Value minus Estimated Risk Post Construction
   - **Prioritization**
     - Prioritization Value (Risk reduction per dollar) =
       - Total Project Costs
       - Project Benefits Factor
         - 1. Environmental Benefits
         - 2. Social Equity Benefits
         - 3. Recreation Benefits
4. Framework

**HAZARD**
- Simplified Annual Probability of Event (AP)

**PERFORMANCE**
- Failure Probability (FP)

**CONSEQUENCES**
- Combined Consequence Risk Value (CCR)

**AP x FP x CCR = Overall Risk Value**

%  Max. Value = 100
4. Framework

\[
\text{Prioritization Value} = \frac{\text{Prioritization}}{\left(\text{Overall Risk Value} - \text{Estimated Risk Post Construction}\right)}
\]

Prioritization Value (Risk reduction per dollar)

- Project Benefits Factor
  1. Environmental Benefits
  2. Social Equity Benefits
  3. Recreation Benefits

\[
\text{Prioritization} = \text{Total Project Costs} 	imes \text{Project Benefits Factor}
\]
5. Data Collection

- Sources
  - Flood damage estimates from Department of Geology and Mineral Industries (DOGAMI)
  - Environmental indicator data from EPA’s EJ Screen
  - Levee Environmental Conditions Assessment Reports
    - Ecosystem Data
    - Species Data
    - Parks and Recreation
  - Geotechnical Analysis Reports
  - Community Asset Inventory
  - Others
6. Develop Alternative Projects

• Primary goals
  ▪ Levee improvements
  ▪ Levee raising
  ▪ Floodwall Repair/Improvement
  ▪ Pump station repair

• Secondary goals
  ▪ Ecosystem restoration/improvements
  ▪ Recreation
  ▪ Social equity
7. Project Analysis

Sample Results - Existing Risk by District

<table>
<thead>
<tr>
<th>District</th>
<th>100yr Risk</th>
<th>500yr Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCDD</td>
<td>60.7</td>
<td>64.7</td>
</tr>
<tr>
<td>PEN1</td>
<td>18.8</td>
<td></td>
</tr>
<tr>
<td>PEN2</td>
<td>36.1</td>
<td>37.9</td>
</tr>
<tr>
<td>SDIC</td>
<td>28.0</td>
<td>32.6</td>
</tr>
</tbody>
</table>

100yr Risk  500yr Risk
7. Alternative Analysis

![Graph showing risk reduction per $100k versus risk valuation. The graph has a coordinate system with axes labeled Risk Reduction per $100k and Risk Valuation. Points A through H are represented by different colored circles, each labeled with a prioritization category: Low Risk / High Prioritization, Low Risk / Low Prioritization, or High Risk / Low Prioritization. Points F and J, for example, are labeled as Low Risk / High Prioritization, while point D is labeled as High Risk / Low Prioritization.]}
Moving Forward

- Finalize calculations and data input
- Analyze sample projects
- Run tool on proposed alternatives
- Final documentation
- Move forward with selected projects