LESSON 8
Learning Outcomes

• Describe scour countermeasure selection based on economic analysis and risk
OBJECTIVE OF PROCESS

- Identifies bridges at risk from scour using existing NBI data
- Prioritizes bridges for countermeasures
- Examines the economic feasibility of scour countermeasure alternatives
PRIORITIZATION

• Two identical bridges except …
  – One has higher ADT
  – One has a longer detour
  – One has higher probability of failure
  – One has higher percentage of trucks
  – A combination of these factors
**RISK**

- **Bridge Situation**
  - Scour Criticality (113)
  - OR
  - Route Class (26)
  - Substructure Condition (60)
  - Channel Protection (61)
  - Waterway Adequacy (71)

- **Bridge Age** (27)

- **Failure Probability**
  - Revised Probability
  - Accounts for age

- **Expected Losses**

- **Economic Factors**
  - Length (49)
  - Width (52)
  - Classification (26)
  - Detour Length (19)
  - Average Daily Traffic (29)

- **Risk ($)**

( x ) = NBI Item
RISK EQUATION

RISK($) = Probability of Failure x Cost of Failure

RISK($) = KP[rebuild cost + running cost + time cost]

\[
RISK (\$) = KP \left[ EC_1WL + C_2DAd + \left( C_3O \left( 1 - \frac{T}{100} \right) + C_4 \frac{T}{100} \right) \frac{DAd}{S} \right]
\]
COST MULTIPLIER FOR EARLY REPLACEMENT

Cost Multiplier

ADT

0 2,000 4,000 6,000 8,000 10,000
EXAMPLE RISK CALCULATION

• Bridge characteristics
  – 40’ wide by 200’ long
  – P=0.0333 (30-year event)
  – ADT = 2500
  – Detour length = 5 miles
  – Percent Trucks = 10 %
## EXAMPLE RISK CALCULATION

<table>
<thead>
<tr>
<th></th>
<th>Bridge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rebuild Cost</td>
<td>$ 720,000</td>
</tr>
<tr>
<td>Running Cost</td>
<td>$ 1,140,000</td>
</tr>
<tr>
<td>Time Cost</td>
<td>$ 1,360,000</td>
</tr>
<tr>
<td>Failure Cost ((C_F))</td>
<td>$ 3,220,000</td>
</tr>
<tr>
<td>Risk (annual expected loss, $)</td>
<td>$ 107,000</td>
</tr>
</tbody>
</table>
PROBABILITY OF FAILURE DURING BRIDGE LIFE

\[ P_L = 1 - (-P) \]
PROBABILITY OF FAILURE DURING BRIDGE LIFE

Useful Life (L) vs. Probability of Failure (P_L)

- P = 0.033 (30-yr)
- P = 0.02 (50-yr)
- P = 0.01 (100-yr)
- P = 0.002 (500-yr)
Benefit = Current Risk – Reduced Risk

\[ B = C_F P_L - C'_F P'_L \]
COUNTERMEASURE SELECTION EXAMPLE

• Compare the benefits of several countermeasure alternatives
## COUNTERMEASURE SELECTION EXAMPLE

<table>
<thead>
<tr>
<th></th>
<th>Existing</th>
<th>CM 1</th>
<th>CM 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>P</strong></td>
<td>0.033 (30-yr)</td>
<td>0.02 (50-yr)</td>
<td>0.01 (100-yr)</td>
</tr>
<tr>
<td><strong>P_L (15-yr)</strong></td>
<td>0.40</td>
<td>0.26</td>
<td>0.14</td>
</tr>
<tr>
<td><strong>Cost of Failure</strong></td>
<td>$ 3,220,000</td>
<td>$ 3,220,000</td>
<td>$ 3,220,000</td>
</tr>
<tr>
<td><strong>Risk</strong></td>
<td>$ 1,228,000</td>
<td>$ 837,000</td>
<td>$ 451,000</td>
</tr>
<tr>
<td><strong>Benefit</strong></td>
<td>$ 451,000</td>
<td>$ 837,000</td>
<td>$ 837,000</td>
</tr>
<tr>
<td><strong>CM cost</strong></td>
<td>$ 100,000</td>
<td>$ 150,000</td>
<td></td>
</tr>
<tr>
<td><strong>Net Benefit</strong></td>
<td>$ 351,000</td>
<td>$ 687,000</td>
<td></td>
</tr>
<tr>
<td><strong>B/C ratio</strong></td>
<td>4.51</td>
<td>5.58</td>
<td></td>
</tr>
</tbody>
</table>
INCLUDING LOSS OF LIFE

- Can be included in Cost of Failure and Risk
- Can be eliminated with appropriate monitoring program
## LOSS OF LIFE AND MONITORING

<table>
<thead>
<tr>
<th></th>
<th>Existing</th>
<th>Monitoring alone</th>
<th>CM 2 and Monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>0.033 (30-yr)</td>
<td>0.033 (30-yr)</td>
<td>0.01 (100-yr)</td>
</tr>
<tr>
<td>$P_L$ (15-yr)</td>
<td>0.40</td>
<td>0.40</td>
<td>0.14</td>
</tr>
<tr>
<td>$C_F +$1m, Life</td>
<td>$4,220,000</td>
<td>$3,220,000</td>
<td>$3,220,000</td>
</tr>
<tr>
<td>Risk</td>
<td>$1,688,000</td>
<td>$1,228,000</td>
<td>$451,000</td>
</tr>
<tr>
<td>Benefit</td>
<td>$400,000</td>
<td>$1,240,000</td>
<td>$1,240,000</td>
</tr>
<tr>
<td>CM cost</td>
<td>$25,000</td>
<td>$175,000</td>
<td>$1,065,000</td>
</tr>
<tr>
<td>Net Benefit</td>
<td>$375,000</td>
<td>$1,065,000</td>
<td></td>
</tr>
<tr>
<td>B/C ratio</td>
<td>16.0</td>
<td>7.1</td>
<td></td>
</tr>
</tbody>
</table>
HYRISK

- Uses NBI database
- Prioritizes bridges
- Estimates probability of failure
- Estimates economic risk
- Evaluates countermeasure benefits
## Scour Countermeasures

### Structure 000000000029535

Define up to seven potential scour countermeasures for use at this bridge site. Then click "Calculate".

<table>
<thead>
<tr>
<th>Name</th>
<th>Cost ($)</th>
<th>RP (y)</th>
<th>Lifetime P(f)</th>
<th>Net Benefit</th>
<th>Benefit/Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do Nothing</td>
<td>$0.00</td>
<td>16</td>
<td>0.6202</td>
<td>$0.00</td>
<td>-- NA --</td>
</tr>
<tr>
<td>Small RR</td>
<td>$50,000.00</td>
<td>25</td>
<td>0.4579</td>
<td>$520,659.13</td>
<td>11.41</td>
</tr>
<tr>
<td>Large RR</td>
<td>$100,000.00</td>
<td>50</td>
<td>0.2614</td>
<td>$966,266.86</td>
<td>10.66</td>
</tr>
<tr>
<td>Monitor</td>
<td>$25,000.00</td>
<td>16</td>
<td>0.6202</td>
<td>$360,489.08</td>
<td>15.42</td>
</tr>
<tr>
<td>Small RR &amp; Monitor</td>
<td>$75,000.00</td>
<td>25</td>
<td>0.4579</td>
<td>$742,372.14</td>
<td>10.90</td>
</tr>
<tr>
<td>Large RR &amp; Monitor</td>
<td>$125,000.00</td>
<td>50</td>
<td>0.2614</td>
<td>$1,064,623.3</td>
<td>9.52</td>
</tr>
</tbody>
</table>

[Buttons: Plot, Cancel, < Back, Report >, Finish]
LEARNING OUTCOMES

• Describe scour countermeasure selection based on economic analysis and risk