

# Mn\DOT CRAVE™



2009 AASHTO VE Conference  
August 31<sup>st</sup> -September 2<sup>nd</sup> , 2009

Nancy Yoo, P.E. - Program Overview  
Ken L. Smith, P.E., C.V.S. – CRAVE™  
Minnie Milkert, P.E. - Lessons Learned



# Events Leading to CRAVE Process



- ◆ August 1, 2007, I-35W bridge collapsed over the Mississippi River.
- ◆ The calamity disrupted transportation, and aimed a spotlight on our nation's public infrastructure system.
- ◆ Legislative session begins in January 2008.
- ◆ Legislative Audit Determinations:
  - Virtually all trunk highway construction funds will need to be directed to preservation projects.
  - Poor scoping and cost estimating

# Events Leading to CRAVE Process



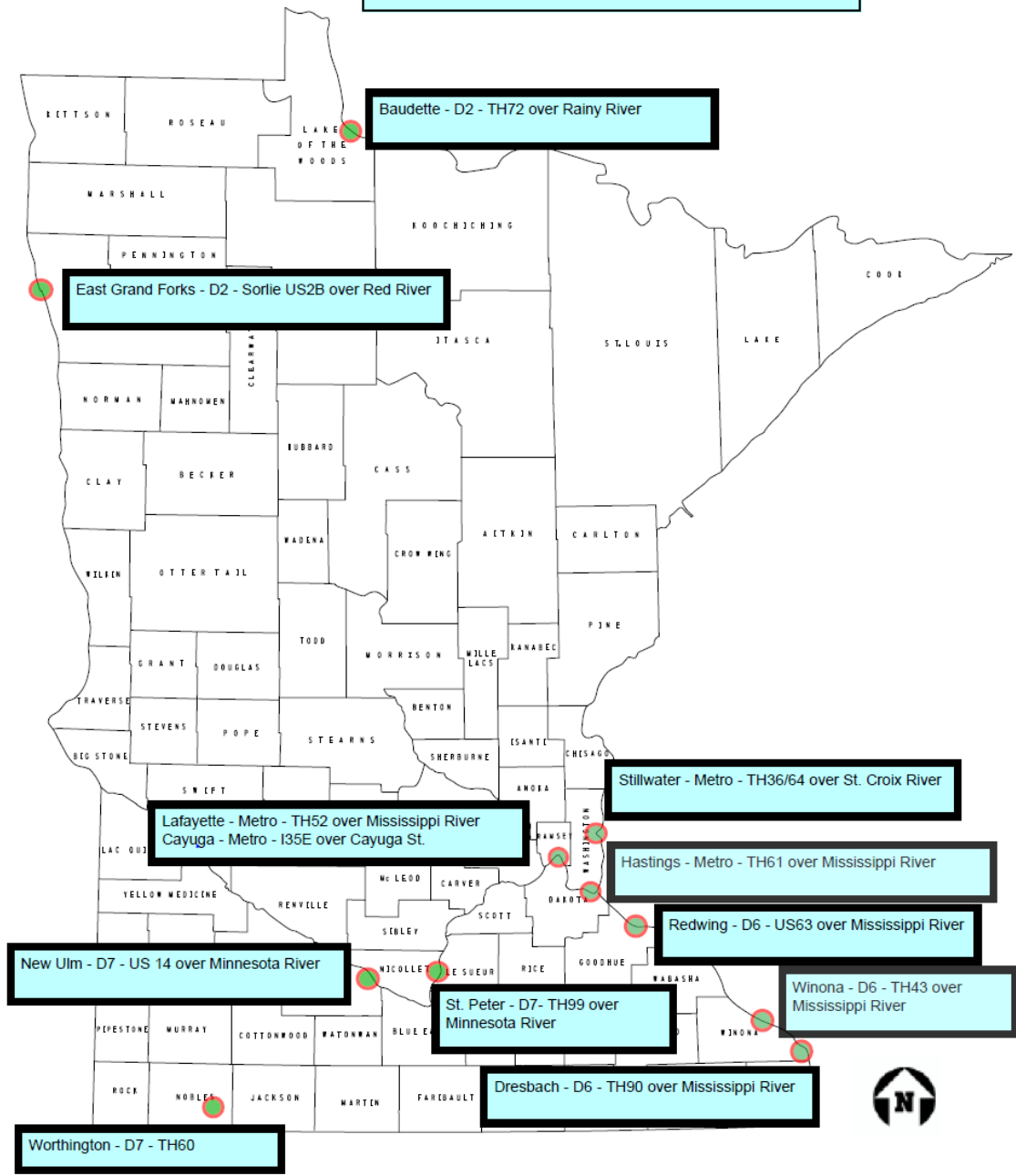
- ◆ Passage of MN Law 2008, Chapter 152
  - Transportation bond appropriations of over \$1.8 billion allocated to DOT over a 10 year-period.
  - Develop a trunk highway bridge improvement program to accelerate repair and replacement of trunk highway bridges throughout the state.
  
- ◆ Cost Estimating, Scoping and Project Delivery Office created.
  - Finish development of Cost Estimating Policy
  - Utilize new Scoping Process
  - Ensure all projects have accurate scope and cost.

# Events Leading to CRAVE Process



- ◆ Commissioner orders cost risk assessments on 12 major bridge and roadway projects (total costs in excess of \$1.9 billion)
  - Projects in various stages of design
  - Some of the projects border other states
- ◆ Value engineering integrated into cost risk assessments
  - In September 2009, we were asked to complete all studies by early December 2009, in time for the 2009 legislative session.
  - Mn/DOT VE Pre-Qualification List
  - HDR hired; Cost Risk Assessment + Value Engineering (CRAVE) process utilized

**CRAVE (Cost Risk Assessment & Value Engineering)  
11 Bridges + One**



# Managing the Program one Project at a Time



Hastings



TH 60



Lafayette



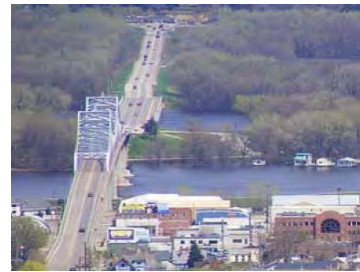
Dresbach



St. Croix



St. Peter



Winona



Cayuga



Red Wing



Sorlie



New Ulm



Rainy River

# The challenge

- ◆ The need to set up and staff 12 Risk assessment and Value Engineering workshops in 3 months
- ◆ Staffing the workshops
- ◆ Logistics



# The Solution was the CRAVE Process



- ◆ The risk assessment is performed on the first day of the study
- ◆ The Quantified results are modeled
- ◆ As part of the VE study the team develops recommendations to mitigate and or avoid risk
- ◆ The risk model is re-ran with the VE recommendations and mitigation strategies
- ◆ The results are presented on the final day



# Comparison of the two processes



Both use a team approach

## Cost Risk Assessment

- ◆ Learn about project
- ◆ Identify Risks
- ◆ Strategize how to handle
- ◆ Qualify and Quantify
- ◆ Develop response plans and triggers



## Value Engineering

- ◆ Investigate
- ◆ Functional analysis
- ◆ Speculate
- ◆ Evaluate
- ◆ Develop

# What is CRAVE™

- ◆ Integrated Process of Cost Risk Analysis & Value Engineering
- ◆ CRAVE™ identifies and quantifies opportunities and threats
- ◆ Outputs are:
  - Risk management plan
  - Value Engineering recommendations



# Why CRAVE™

- ◆ Risk assessment workshops would provide valuable information about what could go wrong with my project but would fall short of providing me solutions on what to do about it
- ◆ Great ideas would come up during risk assessment workshops and would be set aside as potential VE ideas and not recorded
- ◆ The same team members are required for both process



# CRAVE™ Process Key Steps

## Step 1: Baseline Risk Assessment

- ◆ Review Baseline Cost
- ◆ Review Baseline Schedule
- ◆ Identify risks related to baseline project
- ◆ Assess and quantify risks in terms of project's cost and schedule



## Step 2: Value Engineering & Risk Response

- ◆ Develop Value Engineering recommendations that further mitigate or avoid high risk elements
- ◆ Develop recommendations that add value by modifying project scope and/or schedule

## Step 3: Risk Analysis on Response Strategies

- ◆ Identify risks related to Response Strategies
- ◆ Assess and quantify threats and opportunities in terms of project's cost and schedule

## Step 4: Tracking, Monitoring, and Control

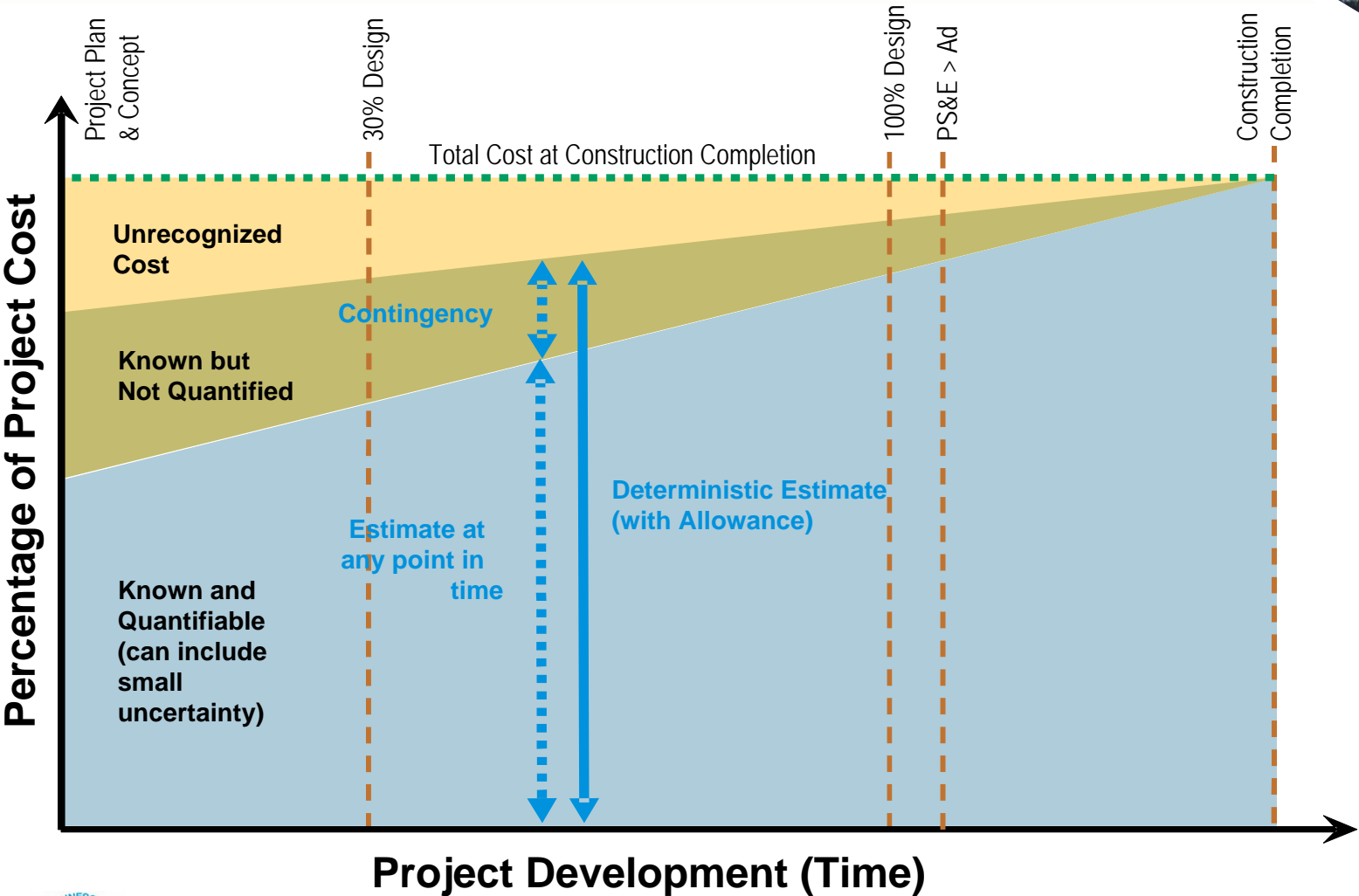
- ◆ Identify Risk Owners, Monitoring Frequency
- ◆ Continuously update risk management plan
- ◆ Document and report progress
- ◆ At Key Milestones, Update Cost and Schedule

# Who Needs to Participate

- ◆ Project Manager
- ◆ Disciplines
  - Construction
  - Bridge & Structures
  - Environmental
  - Right of Way
  - Geotechnical
  - Construction
  - Utilities
  - Local agencies
  - Others depending on project scope



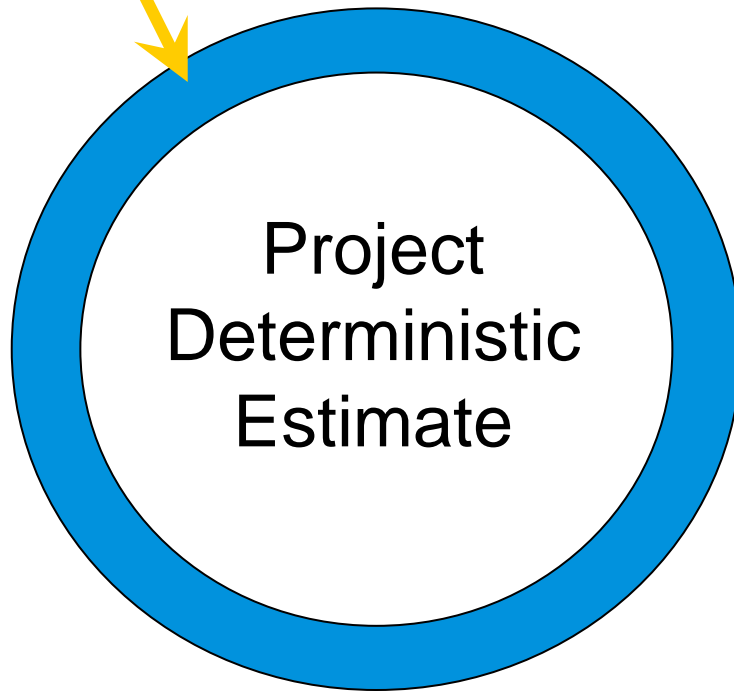
# Assessment of Baseline Cost



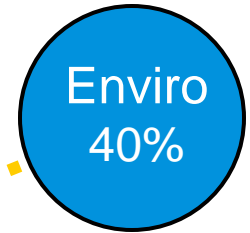
# Traditional Vs. Risk-Based Approach



Fixed Contingency %



Geotech



Project Base Cost



Unknown

# Base Cost

- ◆ The Base Cost represents the cost which can **reasonably be expected if the project materializes as planned.**
- ◆ Base Costs are initially estimated by the Project Team and reviewed during the Risk Workshop by the Subject Matter Experts.

| DRAFT 7-14-08 - Subject to Change |  | 2008 Base Costs |
|-----------------------------------|--|-----------------|
| Phase                             | Cost Elements                                    |                 |
| Phase 1 - Bigelow to Paul Ave.    | Pre-Letting Engineering: Internal - Mn/DOT       | 1,471           |
|                                   | Pre-Letting Engineering: External - Consultants  | 600             |
|                                   | Construction Engineering: Internal - Mn/DOT      | 2,539           |
|                                   | Construction Engineering: External - Consultants | 200             |
|                                   | Project Construction Cost                        | 31,755          |
|                                   | Detour and Haul Roads                            | 1,240           |
|                                   | Right of Way                                     | 5,370           |
|                                   | Utilities  | 120             |
|                                   | Railroads  | 500             |
|                                   | Municipal/Local Issues                           | 0               |
|                                   | Turn-Backs: After                                | 0               |
|                                   | Landscaping                                      | 309             |
|                                   | Environmental Clean-Up/ Mitigation               | 2,341           |
|                                   | Incentives                                       | 1,197           |
|                                   | Change Orders/ Cost Overruns                     | 5,911           |
| <b>Phase 1 Totals</b>             | <b>53,552</b>                                    |                 |

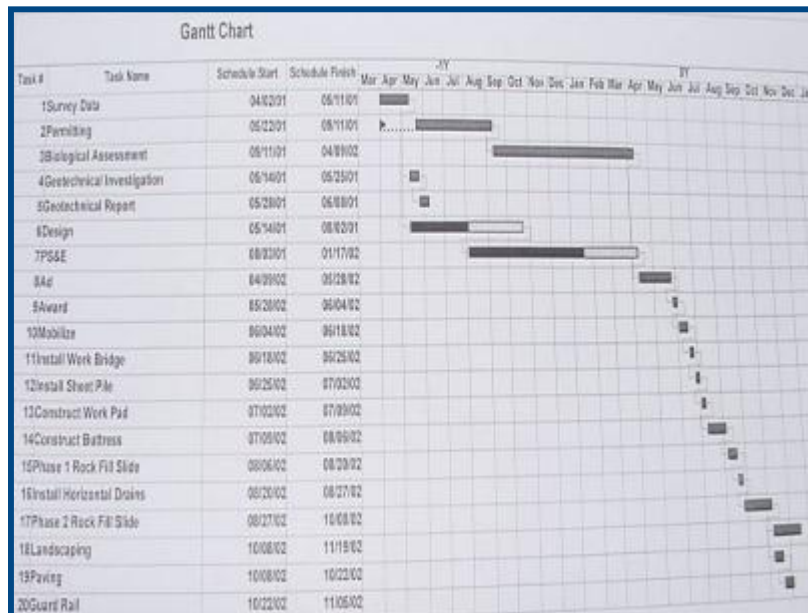




# Risk Management



- ◆ Risk Management is an integral component of day-to-day project management.
- ◆ Project teams implement and **continuously update the Risk Management Plan** throughout the project

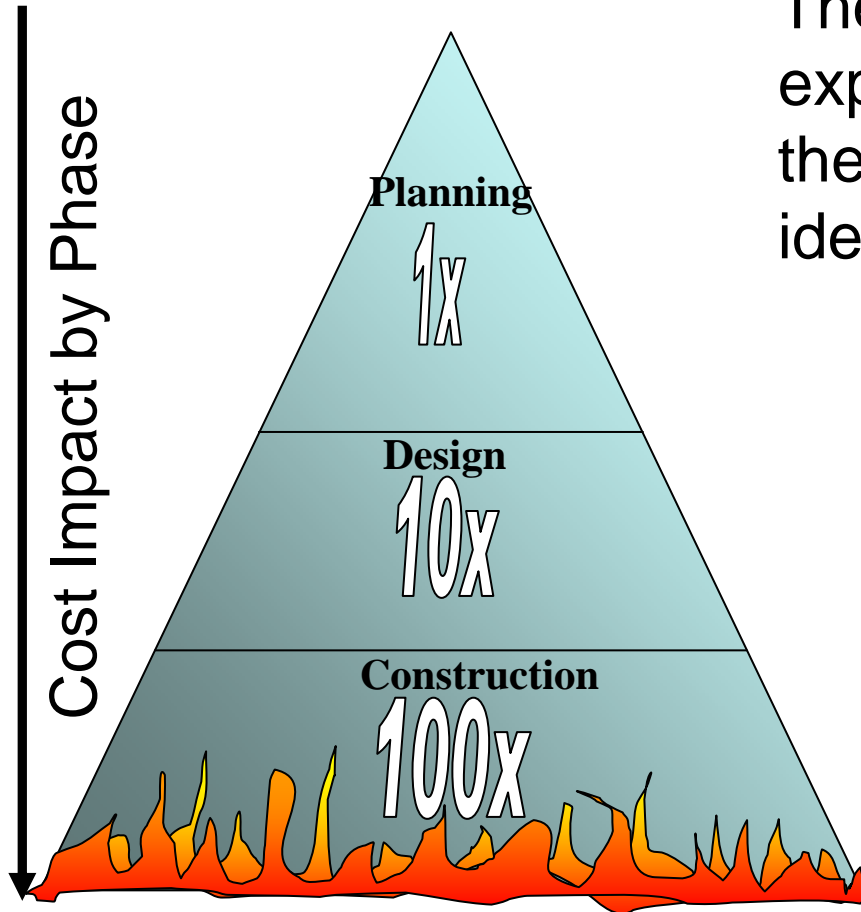


# Why Risk Management?



- ◆ **Maximizing** the probability and consequences (impacts) of **positive** risk events (*opportunities*).
- ◆ **Minimizing** the probability and consequences (impacts) of **negative** risk events (*threats*).

# When to Use



The cost to fix an issue exponentially increases the later in the project lifecycle that it is identified and resolved.

- An issue *identified* in the planning phase costs a factor of 1x to fix
- An issue *identified* in the design phase costs a factor of 10x to fix
- An issue *discovered* during construction costs a factor of 100x to fix

# Elicit Risks

Caution needs to be exercised when eliciting risks. While the Risk Lead must be thorough in making sure to capture uncertainty and risk, he or she must also guard against the potential of double-counting.

**The use of an expert risk elicitor is strongly advised**



# Quantitative Risk

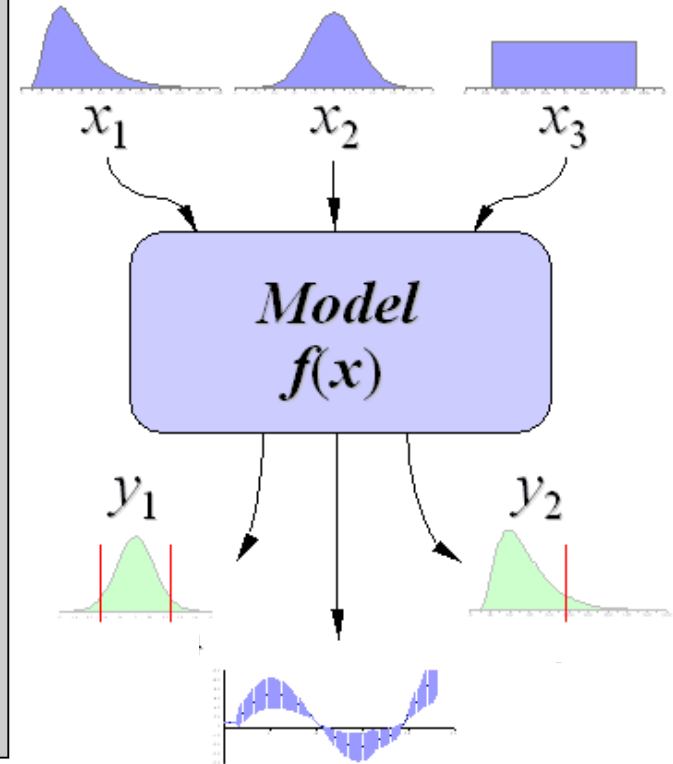
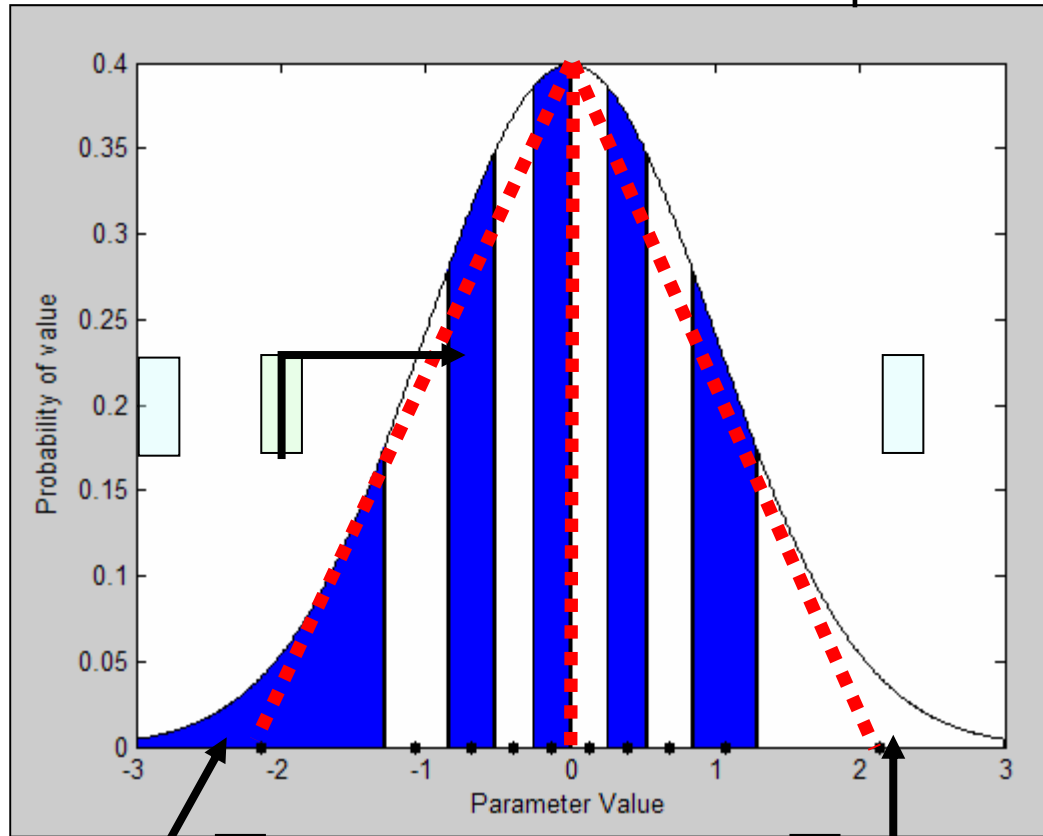


|          |     |            |          |        |           |             |  |
|----------|-----|------------|----------|--------|-----------|-------------|--|
| Cost     | 75% | MIN        | 5.00\$M  | 8\$M   | High      | Probability |  |
|          |     | MAX        | 25.00\$M |        |           |             |  |
|          |     | BEST GUESS | 10.00\$M |        |           |             |  |
| 2        |     | 0          |          |        | High      |             |  |
| Schedule |     | MIN        | 12.0Mo   | 27.0Mo | Very High | Impact      |  |
|          |     | MAX        | 48.0Mo   |        |           |             |  |
|          |     | BEST GUESS | 36.0Mo   |        |           |             |  |

# What is Monte Carlo?



Expected Value (Mean)



Lowest Likelihood

80% Range

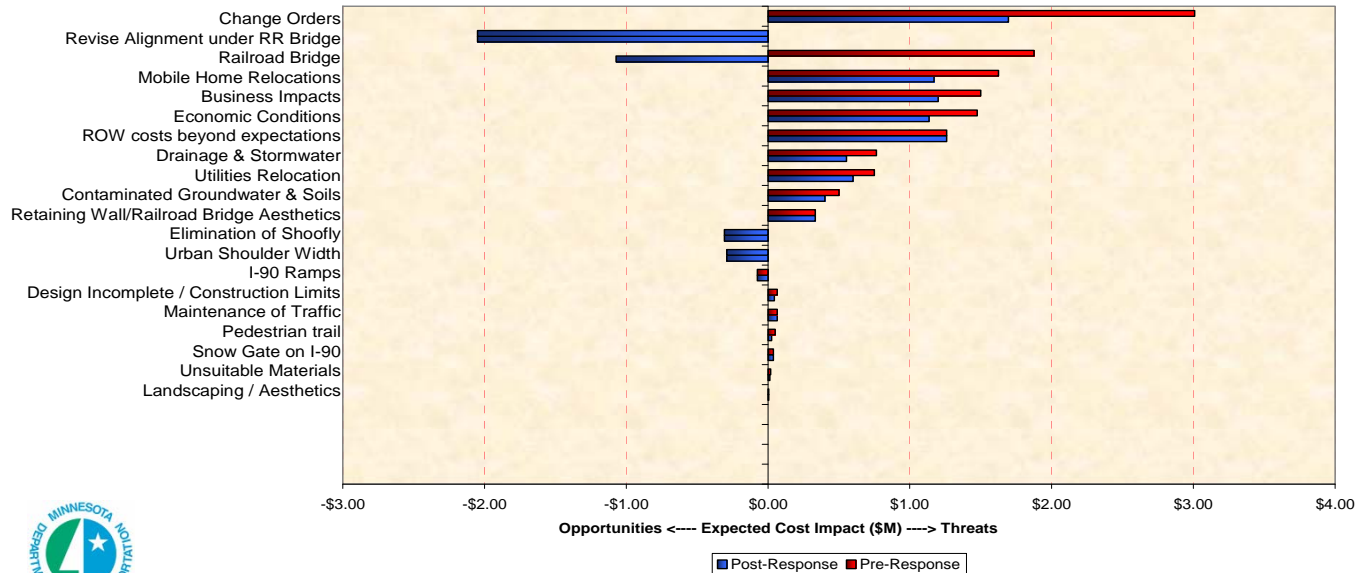
Lowest Likelihood

# Prioritizing Risk



- ◆ We often spend a considerable amount of resources on a risk that may not have large impact
- ◆ By quantifying your project risks you can apply the limited resources to the risks that can provide the largest return
- ◆ Tornado Diagrams are a great way to see this graphically

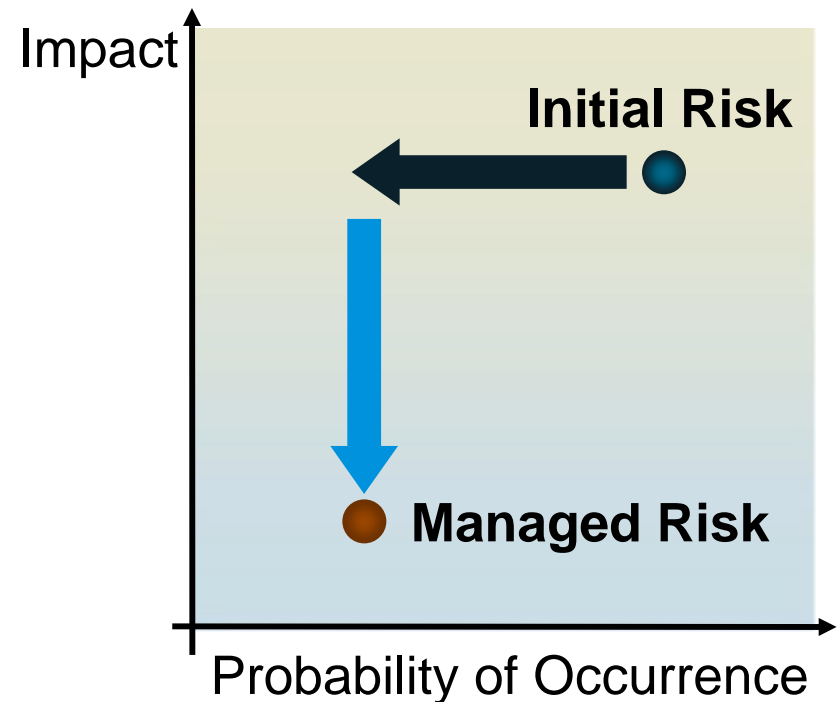
Cost Risk Ranking - Pre and Post Response



“What gets measured, gets managed”

# Goal of Risk Management

- ◆ Risk Assessment's aim is to assess potential impact of various scope, event, and budget risks on the project's cost and schedule.
- ◆ Risk Management's aim is to identify opportunities and mitigation strategies to reduce both the likelihood of an event occurrence and the potential effect if it occurs.





# Managing the Program one Project at a Time



Hastings



TH 60



Lafayette



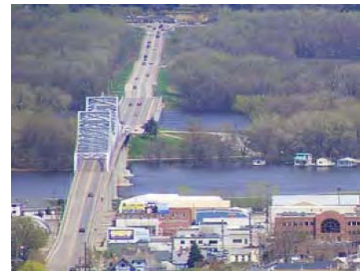
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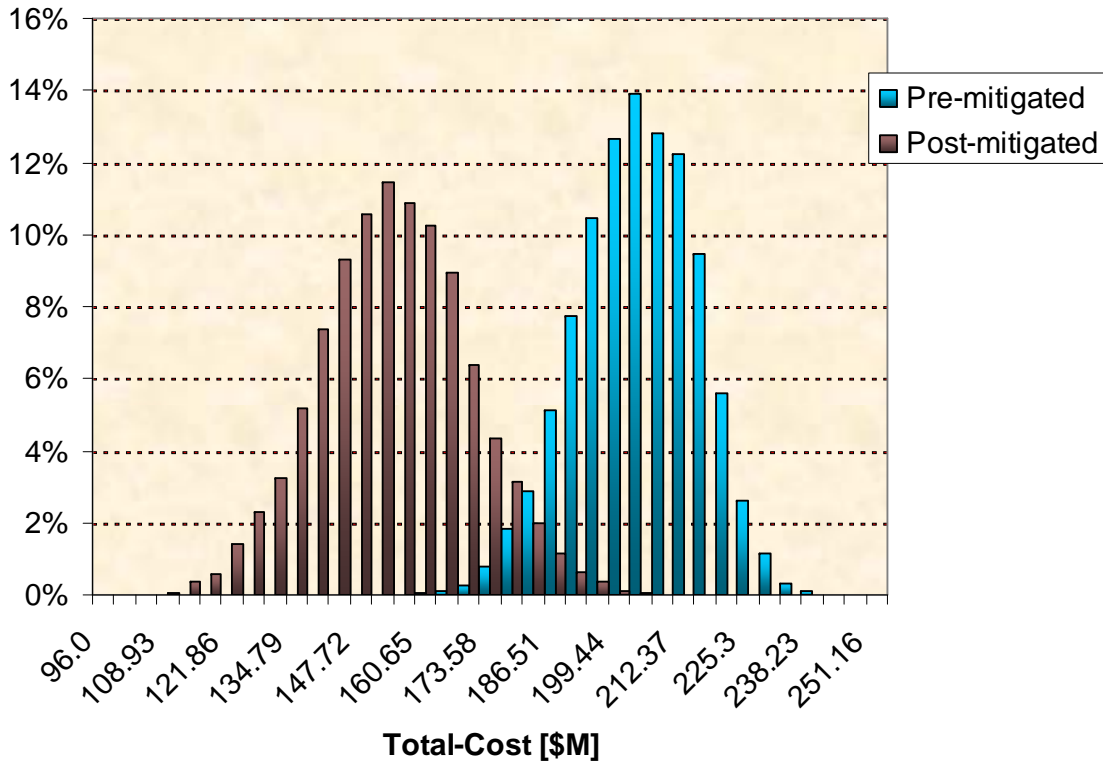


Rainy River



# Post-Mitigation + VE Recommendations

**Total Cost  
Current Year (CY)**

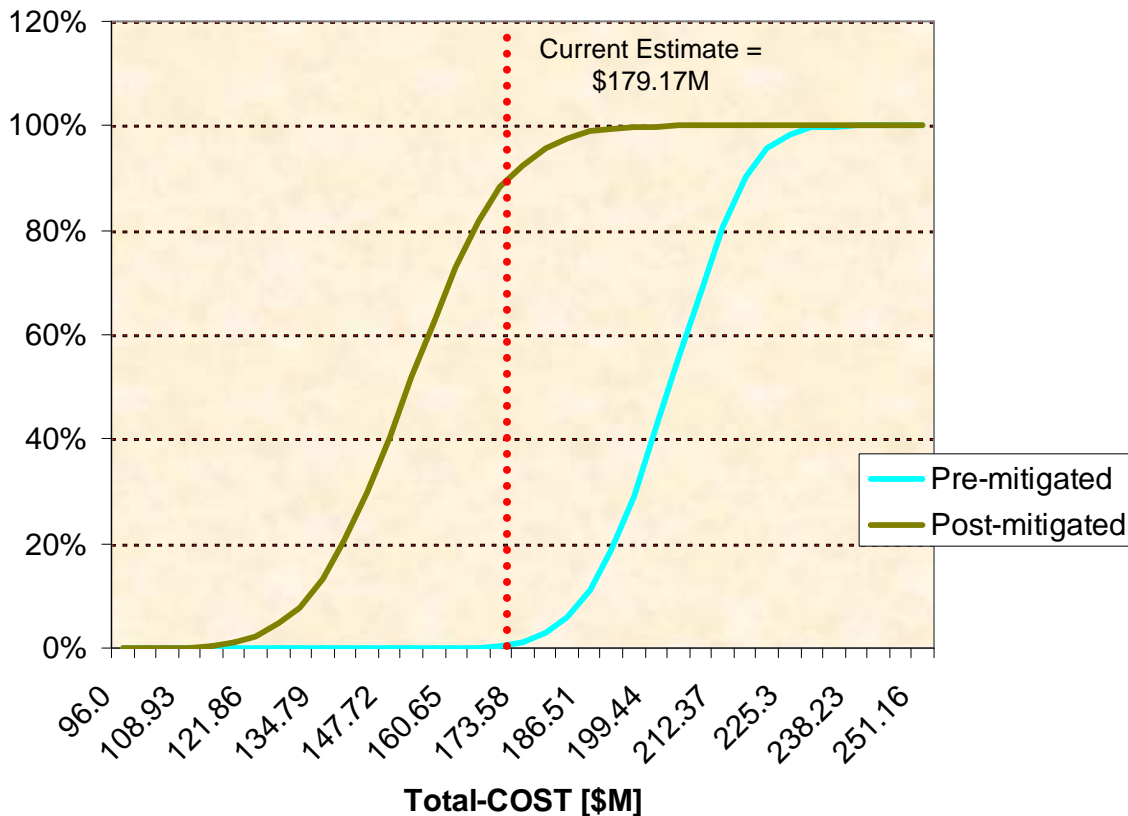


| Total Project Cost Range |                   |                   |
|--------------------------|-------------------|-------------------|
|                          | Pre-mitigated     | Post-mitigated    |
| <b>Min</b>               | <b>157.28 \$M</b> | <b>101.31 \$M</b> |
| <b>Max</b>               | <b>242.09 \$M</b> | <b>217.80 \$M</b> |
| <b>Median</b>            | <b>202.12 \$M</b> | <b>148.60 \$M</b> |
| <b>10%</b>               | <b>185.73 \$M</b> | <b>129.93 \$M</b> |
| <b>20%</b>               | <b>191.61 \$M</b> | <b>135.95 \$M</b> |
| <b>30%</b>               | <b>195.77 \$M</b> | <b>140.45 \$M</b> |
| <b>40%</b>               | <b>199.01 \$M</b> | <b>144.49 \$M</b> |
| <b>50%</b>               | <b>202.12 \$M</b> | <b>148.60 \$M</b> |
| <b>60%</b>               | <b>205.09 \$M</b> | <b>152.73 \$M</b> |
| <b>70%</b>               | <b>208.39 \$M</b> | <b>157.81 \$M</b> |
| <b>80%</b>               | <b>211.93 \$M</b> | <b>166.70 \$M</b> |
| <b>90%</b>               | <b>216.70 \$M</b> | <b>181.27 \$M</b> |

# Post-Mitigation + VE Recommendations



### Total Cost - Current Year (CY)



| Total Project Cost Range |                   |                   |
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| <b>90%</b>               | <b>216.70 \$M</b> | <b>181.27 \$M</b> |

# Lessons Learned



- ◆ Do not short change the process
- ◆ Additional studies may be required as projects progress
- ◆ Use VE team set up check list and Request for VE form, circulate check list of items and information needed for the team
- ◆ Have project team prepare and deliver an accurate overview of the project
- ◆ Accurate cost estimate validated prior to study

# Lessons Learned



- ◆ Project team selection is critical
- ◆ Subject matter experts from around the nation filled in as CRAVE team members; their expertise was invaluable and allowed Mn/DOT personnel to stay in their office to deliver critical bonding projects.
- ◆ Having the economist at the CRAVE workshop definitely accelerated the completion of the CRAVE studies.
- ◆ CRAVE training that followed the studies helped reinforce the participant's understanding of the risk assessments and risk management plan.

11 Bridges + 1 (TH 60)  
Chapter 152  
Cost Risk Assessment Value Engineering (CRAVE) Plan

| Location                     | Dist  | Study Facility Location | Mid - Year Construction Date        | 15-Sep        | 22-Sep | 29-Sep | 06-Oct     | 13-Oct    | 20-Oct                  | 27-Oct                   | 03-Nov | 10-Nov                     | 17-Nov    | 24-Nov | 01-Dec        | 08-Dec            | 18/19 Feb          |              |  |           |  |
|------------------------------|-------|-------------------------|-------------------------------------|---------------|--------|--------|------------|-----------|-------------------------|--------------------------|--------|----------------------------|-----------|--------|---------------|-------------------|--------------------|--------------|--|-----------|--|
| Hastings                     | Metro | Hastings City Hall      | 2011                                |               |        |        |            | Ken Smith | Consultants Unavailable | Design Engineers Meeting |        | Veterans Day is on Tuesday |           |        |               |                   | Final Presentation |              |  |           |  |
| Lafayette St. Paul           | Metro | Maryland Truck Station  | 2012                                | HDR-Ken Smith |        |        |            |           |                         |                          |        |                            |           |        |               |                   |                    |              |  |           |  |
| TH 99 St. Peter              | D7    | Maryland Truck Station  | 2013                                |               |        |        |            |           |                         |                          |        |                            | Cost Risk |        |               |                   |                    | VE-Ken Smith |  |           |  |
| Dresbach La Crescent         | D6    | OnAlaska Wisconsin      | 2014                                |               |        |        | Don Owings |           |                         |                          |        |                            |           |        |               |                   |                    |              |  |           |  |
| St. Croix                    | Metro | Oakdale Bridge Office   | 2015                                |               |        |        |            |           |                         |                          |        |                            |           |        | HDR-Ken Smith |                   |                    |              |  |           |  |
| Winona                       | D6    | Winona / Rochester MN   | 2016                                |               |        |        |            |           |                         |                          |        |                            |           |        | Don Owings    | Thanksgiving week |                    |              |  |           |  |
| Cayuga St. Paul              | Metro | Maryland Truck Station  | 2016                                | HDR-Ken Smith |        |        |            |           |                         |                          |        |                            |           |        |               |                   |                    |              |  |           |  |
| Red Wing                     | D6    | Red Wing / Rochester MN | 2018                                |               |        |        |            |           |                         |                          |        |                            |           |        | Don Owings    |                   |                    |              |  |           |  |
| US 14 New Ulm                | D7    | Maryland Truck Station  | 2018                                |               |        |        |            |           |                         |                          |        |                            | Cost Risk |        |               |                   |                    | VE-Ken Smith |  |           |  |
| Rainy River Baudette         | D2    | Maryland Truck Station  | 2019                                |               |        |        |            |           |                         |                          |        |                            | Cost Risk |        |               |                   |                    | VE-Ken Smith |  |           |  |
| Kennedy Sorlie E Grand Forks | D2    | Maryland Truck Station  | 2019                                |               |        |        |            |           |                         |                          |        |                            | Cost Risk |        |               |                   |                    | VE-Ken Smith |  |           |  |
| TH 60 Worthington            | D7    | Mankato                 | multiple lettings 2010, 2011 & 2012 |               |        |        |            |           |                         |                          |        |                            |           |        |               |                   |                    |              |  | Ken Smith |  |

Note: These projects will be studied in a split CRAVE study at Maryland Ave. Truck Station. 4 days of Cost Risk Assessment Nov. 3 thru 6 followed by 5 days of Value Planning Dec. 1 thru 5.  
St. Peter - Monday, Nov. 3 & Dec. 1; New Ulm - Tues Nov. 4 & Dec. 2; Rainy River - Wed. Nov. 5 & Dec. 3; Kennedy - Thurs. Nov. 6 & Dec. 4. Final presentation

Note: These projects will be studied consecutively, Mon/Tues in Winona, Wed/Thurs in Red Wing, Fri "Presentation of Findings" in Rochester.

Note: Roadway project

Revised 06/15/09

# Lessons Learned

## ◆ Planning

- Hiring the consultant and the contracting process
- Selecting the teams
- 4500+ e-mails
- Hundreds of phone calls
- Scheduling hotels and working lunches
- Reserving vehicles for the site visit
- BlackBerry
- Even considered the state plane

# Lessons Learned

- ◆ The CRAVEs would not have been a success without support from everyone – team members, consultant and management.
- ◆ Selecting teams was difficult with the high work load. First time using consultant team members. This worked very well.
- ◆ Admin and contract follow up. Important to have a good scope of services, cost estimate, agenda, etc. for getting the contract through quickly.



# Lessons Learned

- ◆ Follow up with PM's for decisions
- ◆ Have forms ready to go
  - VE request form for project info
  - Checklist to make sure nothing gets missed
  - DRAFT VE report comments form
  - PM Decision matrix

**We are seeing a cultural change  
from: “have to do” to “want to do”**



# QUESTIONS?

