

# **CRAVE**

## **Cost Risk Assessment + Value Engineering**

CSVA 2011 Conference  
Toronto, Ontario  
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# Topic Overview

- *marketing statement, what is in it for me, my organization, why should I listen...*
- *what the problem was...*
- *what I will learn...*
- *What we did...*
- *Closing statement...*

# Addressing Cost and Schedule Concerns



Usual  
Questions

- How much will it cost?
- How long will it take?
- Why does it cost that much?
- Why does it take that long?

Analysis  
Needs

- Risk Identification
- Qualitative and Quantitative Risk Analysis
- Value Engineering & Mitigation Strategies
- Risk Monitoring & Control

# What is CRAVE

- CRAVE is used to assist project delivery as well as minimize and mitigate quantified risks
- CRAVE - innovative unique process
  - Cost Risk Analysis + Value Engineering
    - Combines these two tools to assist with project delivery
- 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 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
- Value Engineering could add risk to delivering a project
- The same team members are required for both process

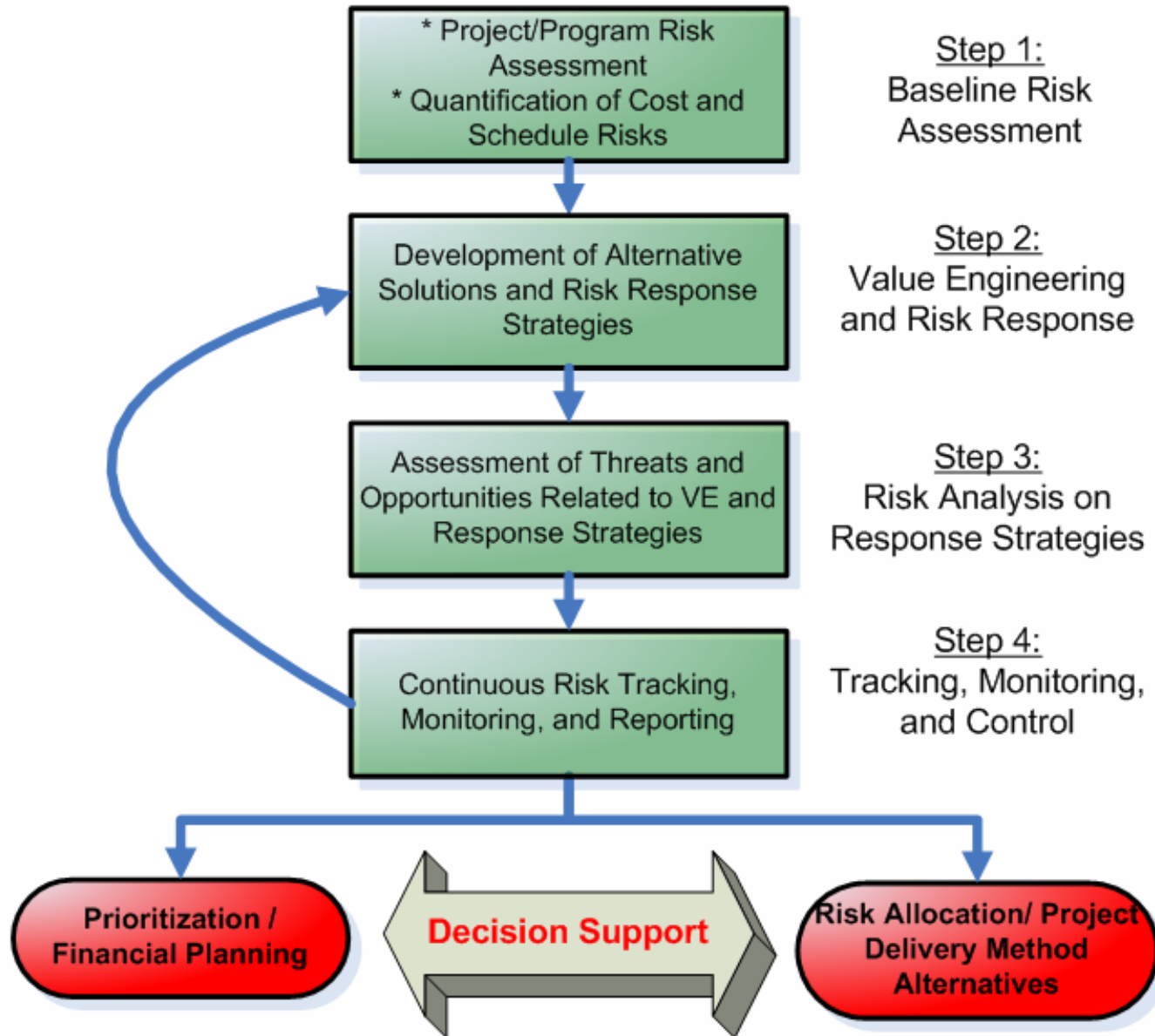


# Proven Process

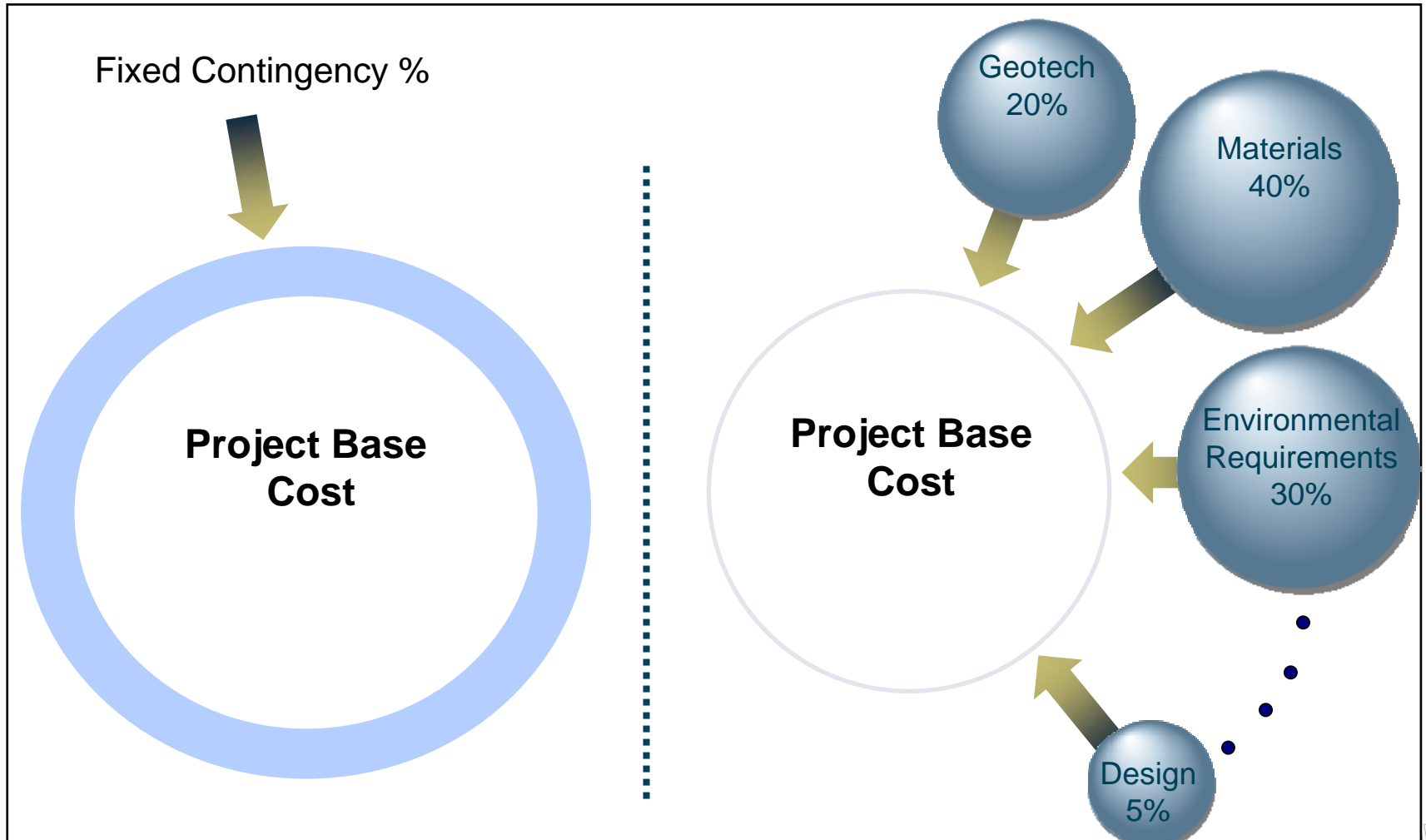
- Proven results on a wide range of projects, including bridges, highways, heavy and light rail alignments, ports, airports, tunnels, water treatment facilities, and pipelines
- Won national awards for process



# CRAVE How it works



# Traditional Vs. Risk-Based Approach





# CRAVE Process: Step 1

Risk Register By Project and Category  
(Executive, Stakeholders, and technical Risks)

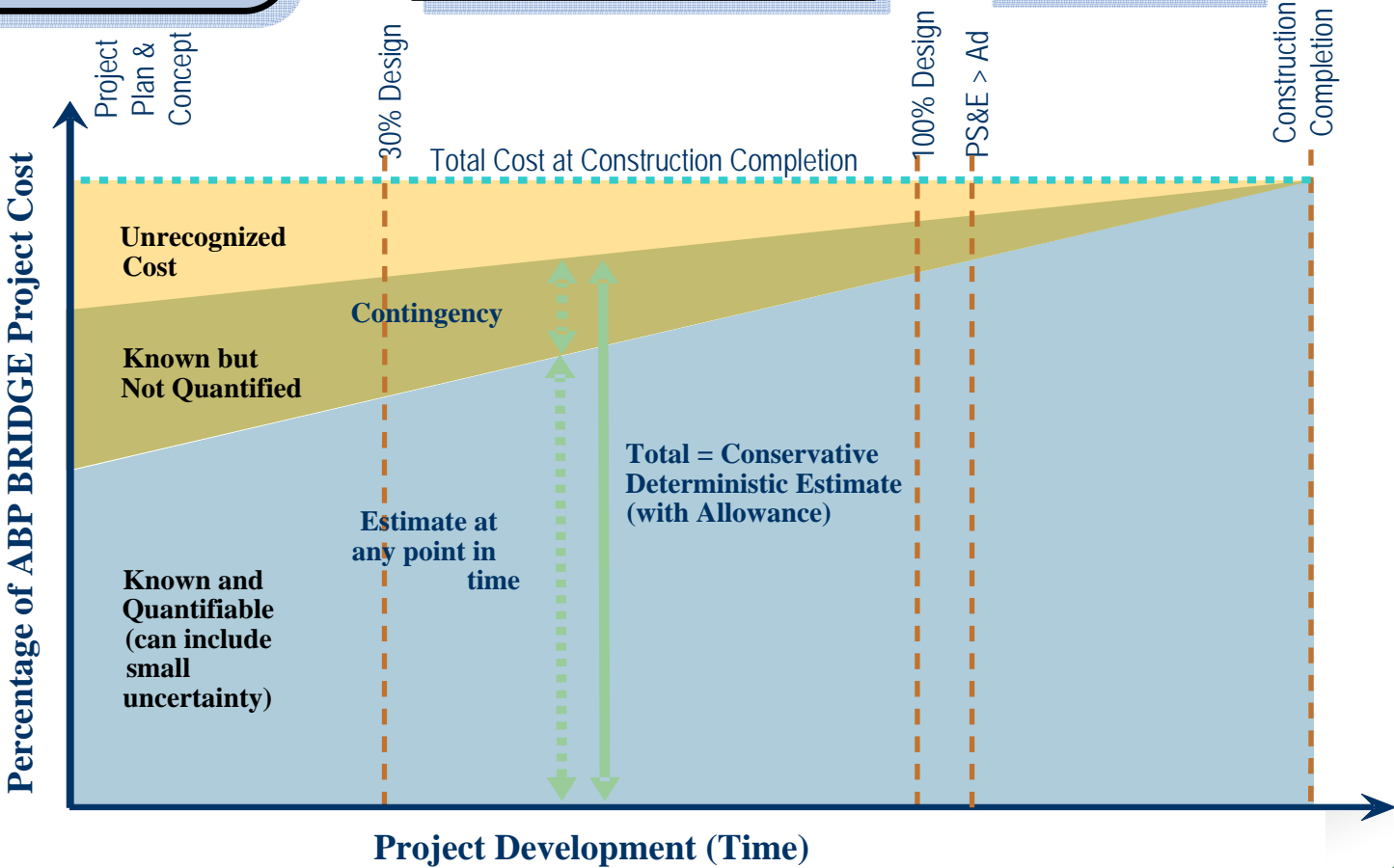
Project-Specific Escalation Based on Bid Prices  
Trends and Markey Analysis

\* Project and Program Level Risk Assessment  
\* Quantification of Cost and Schedule Risks

Cost and Schedule Estimates

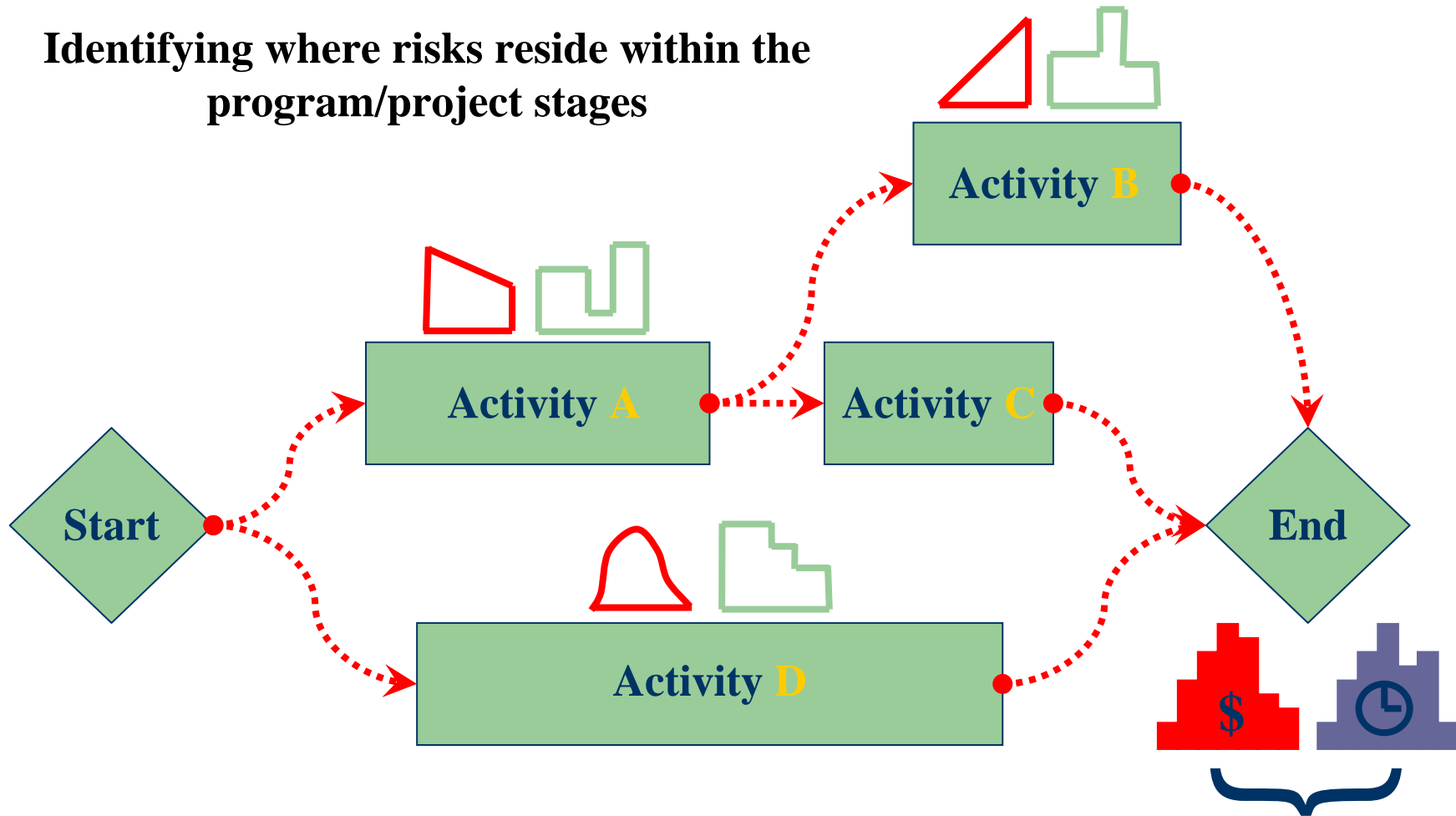
Projects Characteristics

Step 1:  
Baseline Risk Assessment

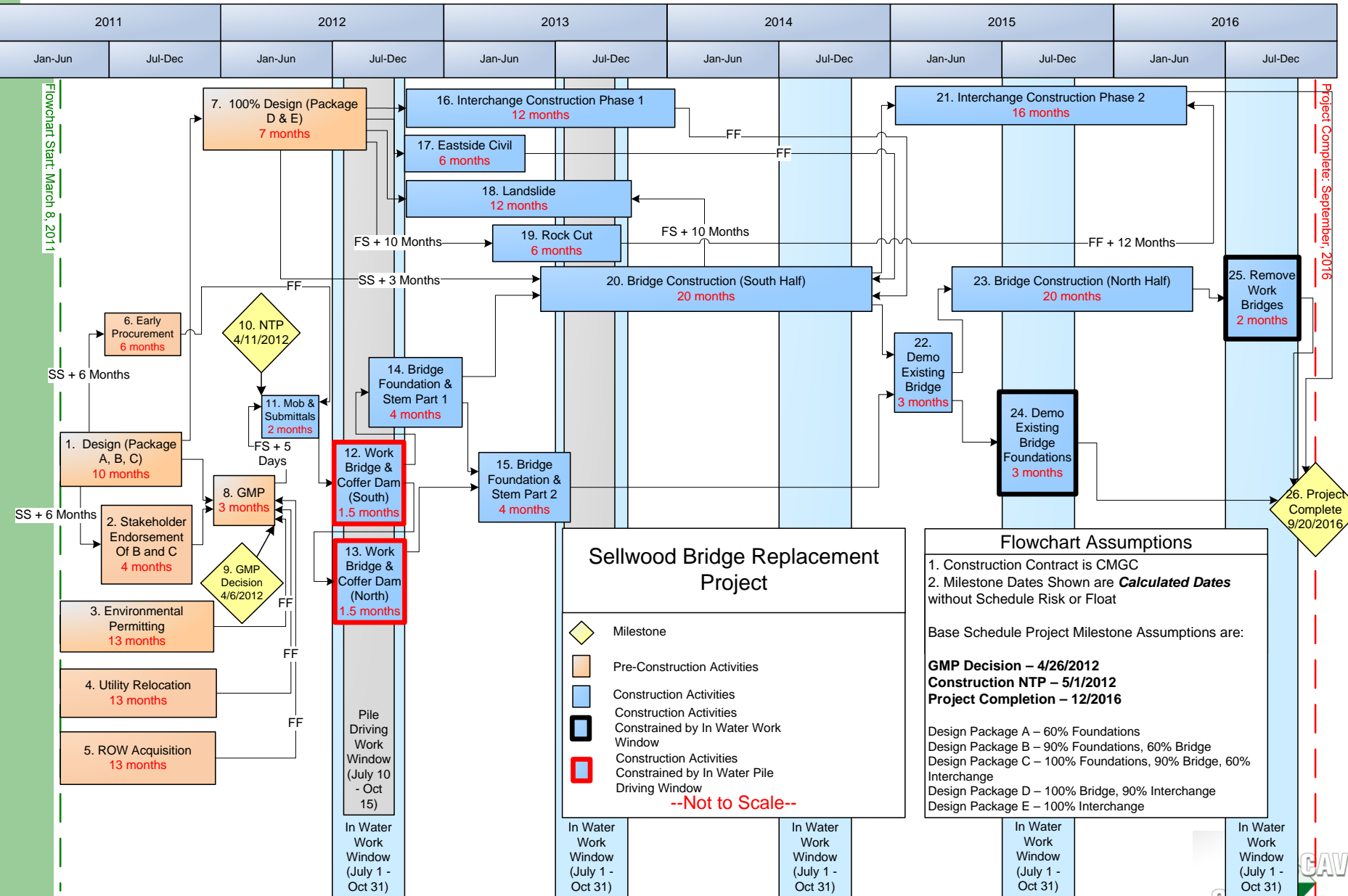


# Need for a Solid Flowchart

Identifying where risks reside within the program/project stages



# Project Schedule Flowchart



# Comprehensive Risk List at Each Stage

Planning	Programming	Preliminary Design	Final Design	A/B/A	Construct
Environment		Geotechnical		Contracts	
Right of Way		Structures		Insurance/	
Governance/Stakeholders		Pavements		Bonds	
Financing		Hydraulics		Construction	
Civil & Environmental Justice		Stormwater		Methods	
Multi-modal Systems		Tunnels		MOT	
Teaming		Intelligent Transportation		Market Conditions	
Options/Alternatives		Permitting		Disputes	
				Weather	
				Security	

# Consensus-Based Workshops

- Structured Workshops to Build Consensus Among Various Stakeholders
- Engagement of Internal and External Subject-Matter Experts
- Sessions by Functional Assignment to:
  - Identify Risks
  - Quantify Risks
  - Discuss Risk Response and Mitigation Strategies



# Risk Elicitation

- **Focus on issues that matter**
- **Describe the event properly**
- **What will trigger the event?**
- **How likely is it to occur?**
- Is the event dependent on or correlated with other events?
- What are the potential impacts (cost/schedule)?
- If the event occurs what are the impacts
  - on the low end?
  - on the upper end?
  - most likely?

# Quantitative Risk

**Project:** Floating Bridge and Landings

**Risk ID:** FB FB STG 900.07

**Sub-Project:** FB

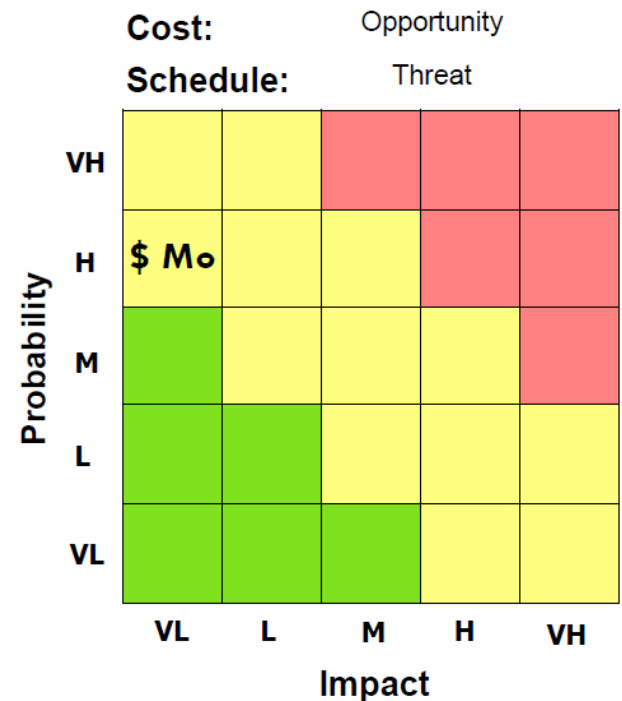
*Issues with design and constructability of Maintenance facility*

**Risk Trigger:**

Pre-Response Quantification

Probability			Cost		Project Risk Rank
Min (\$M)	Most Likely (\$M)	Max (\$M)	Expected Value Impact (\$M)		
80%					
(\$0.750)	(\$0.200)	\$0.250	(\$0.173)		9
Schedule			Schedule		Program Risk Rank
Min (MO)	Most Likely (MO)	Max (MO)	Expected Value Impact (MO)		
1.00	2.00	3.00	1.60		44

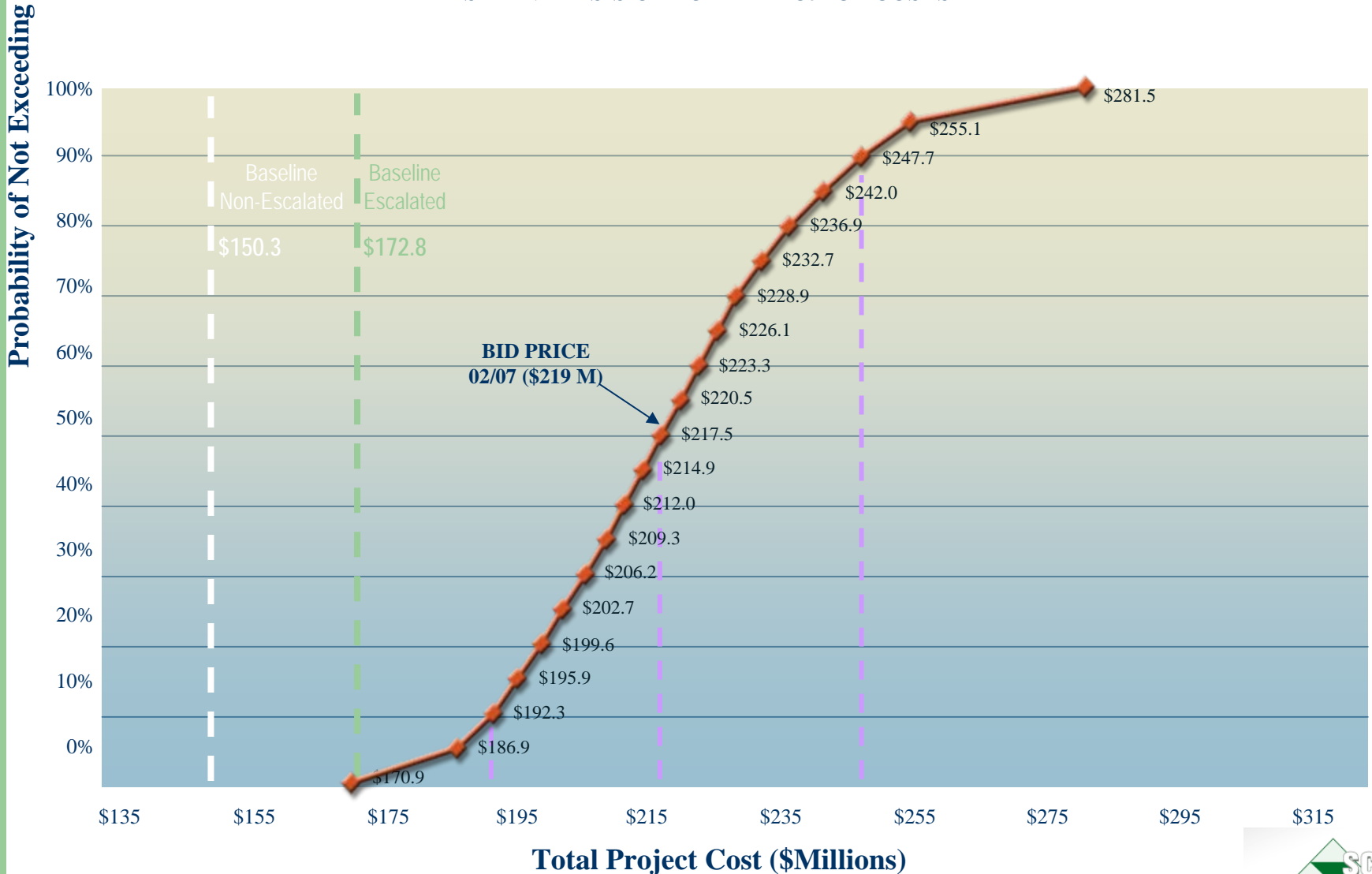
Wall is nearly 70' tall, there could be issues with groundwater, excavation of spoils in front of the wall. Soil is very fine and if it's too saturated may not be able to get equipment into and out of the area. If soldier pile wall is used there could be localized caving due to running of the fine sand, would have to design to seal this off to prevent caving. Risk covers all uncertainties related to the Maintenance Building, Related Walkways and Mooring Dock Facilities. Groundwater is upwelling in the lake and supporting salmon spawning and resource agencies want this to continue. this may require raising the facility and associated docks. By raising it could be less dewatering Medina may push back on a facility that is higher.



# CRAVE Process: Step 1

## Non-Mitigated Risk-Adjusted Cost Estimates

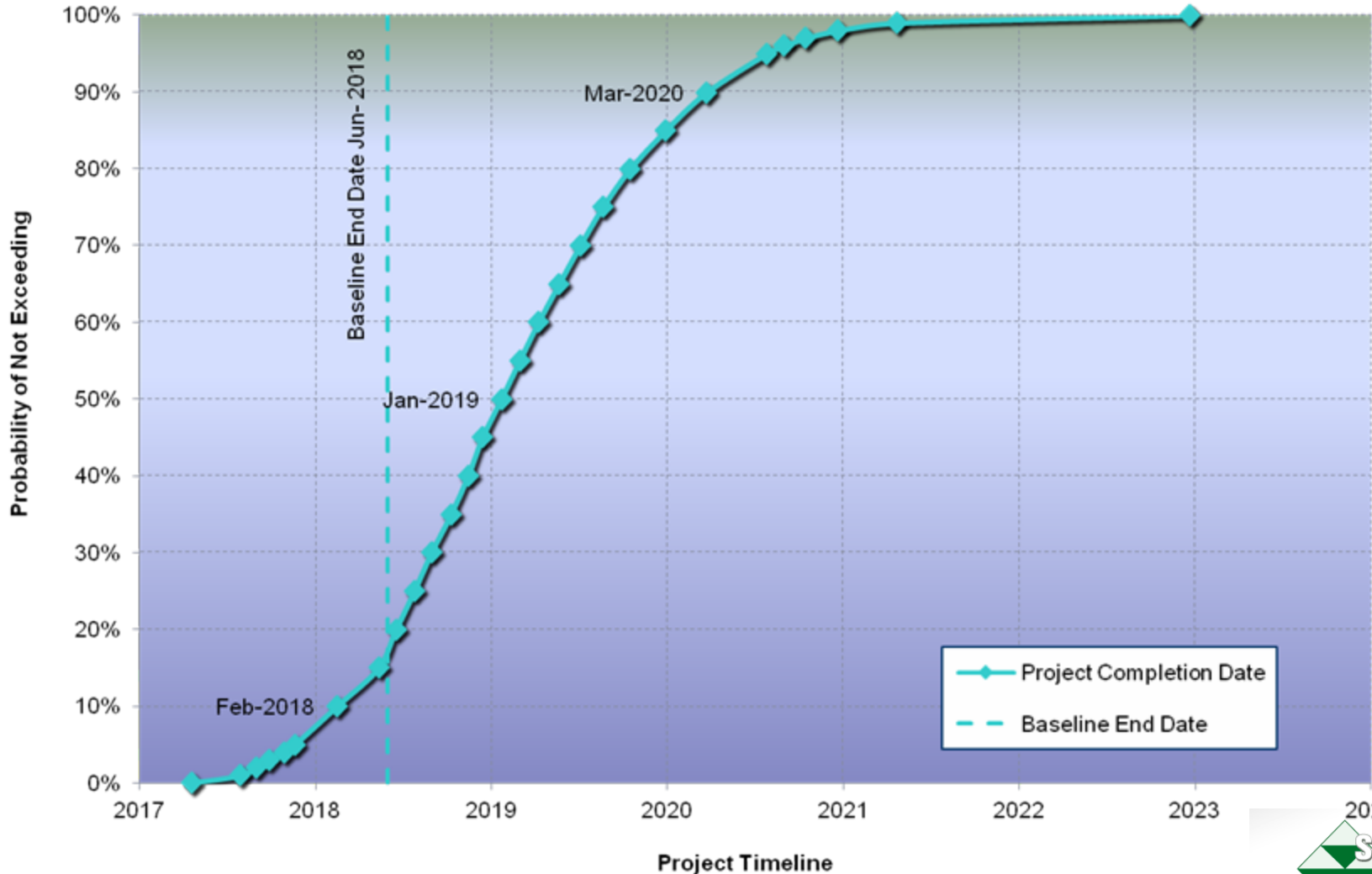
RISK ANALYSIS OF TOTAL PROJECT COSTS





# Baseline Risk Assessment

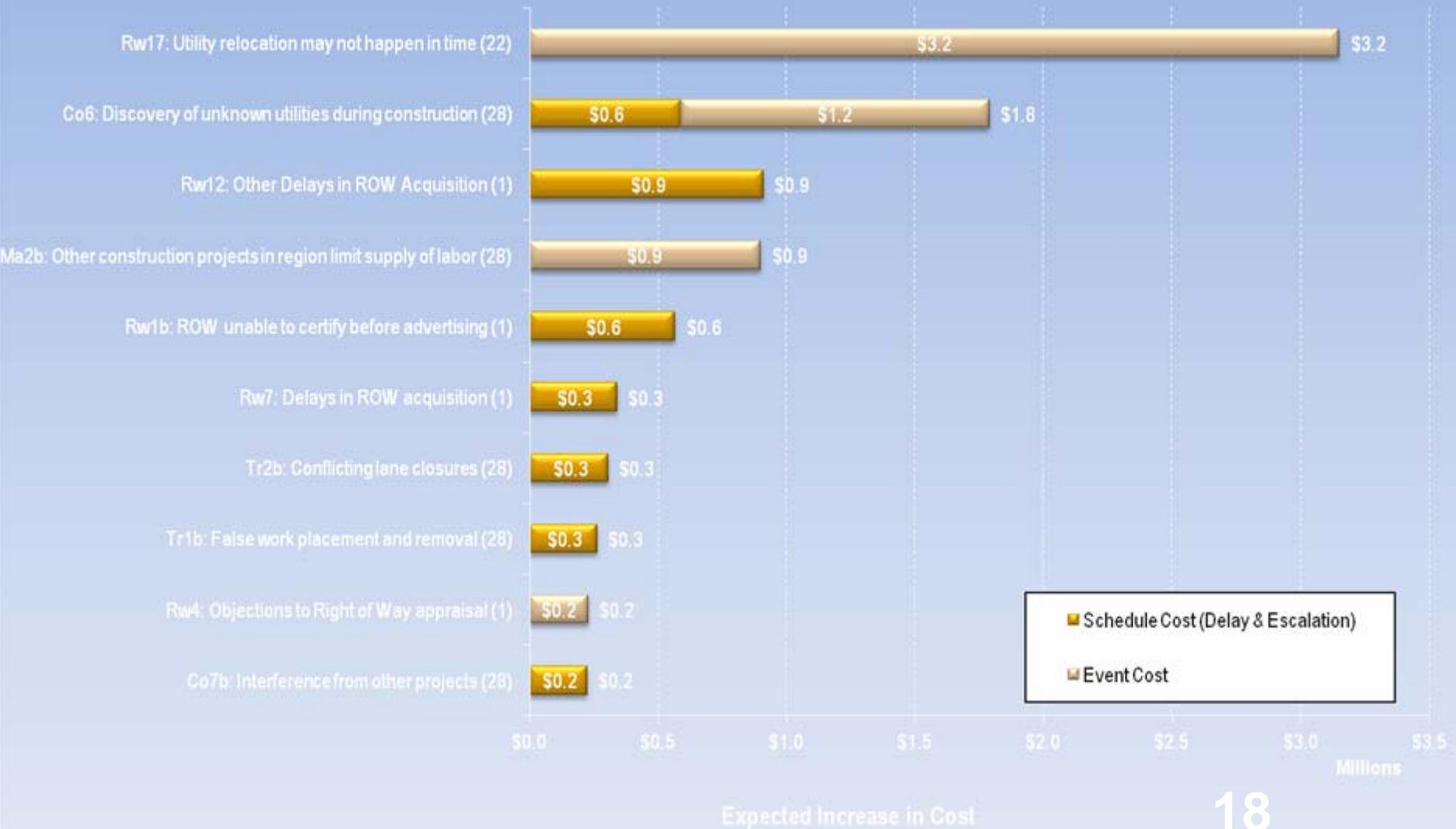
## Risk-Adjusted *Schedule Projection*



# CRAVE Process: Step 1

## Prioritization of Risks

### Top Cost Impacts on Cost - Event Costs and Schedule Delay Costs



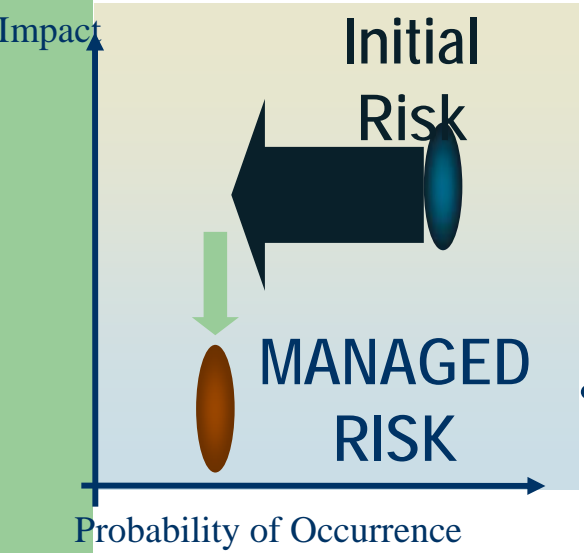
# CRAVE Process: Step 2

## Value Engineering Assessment

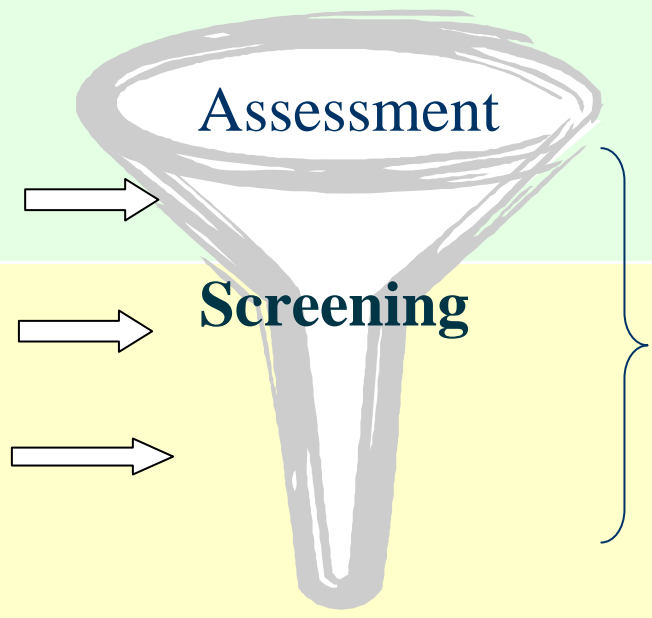


Step 2:  
Value Engineering  
and Risk Response

## Project Review

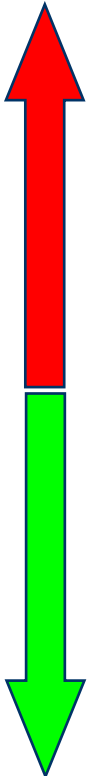


- High cost areas
- Generate ideas
- Evaluate ideas
- Quantify Ideas



# WHAT IS VALUE?

Value Engineering has traditionally been perceived as an effective means for reducing project costs.

$$\text{Value} = \frac{\text{Performance}}{\text{Cost}}$$


This only addresses one part of the value equation, often times at the expense of reducing performance.

# ***PERFORMANCE ATTRIBUTES***

Establishing the Goals and Objectives of VE Study is critical to its outcome.

Defining “Performance Attributes” will give the VE Team a better understanding of the project’s purpose and need.

## ***Typical Highway Performance Attributes***

- **Mainline Operations**
  - **Local Operations**
  - **Maintainability**
- **Construction Impacts**
- **Environmental Impacts**
  - **Project Schedule**
  - **Reduce Risk**



# ALTERNATIVE ANALYSIS

## PERFORMANCE ATTRIBUTE MATRIX

### Midway Road - CR 712 Project

Which attribute provides the greatest benefit to the project relative to purpose and need?

								TOTAL	%	
Mainline Operations		A	A	A	A	A/E	A	A	6.5	24%
Local Operations		B		B	B	B/E	B	B	5.5	20%
Maintainability		C		C	E	C	C		4.0	14%
Construction Impacts		D		E	D/F	G			1.5	5%
Environmental Impacts		E		E	E				6.0	21%
Project Schedule		F		G					1.5	5%
Risks		G							3.0	11%
								28.0	100%	

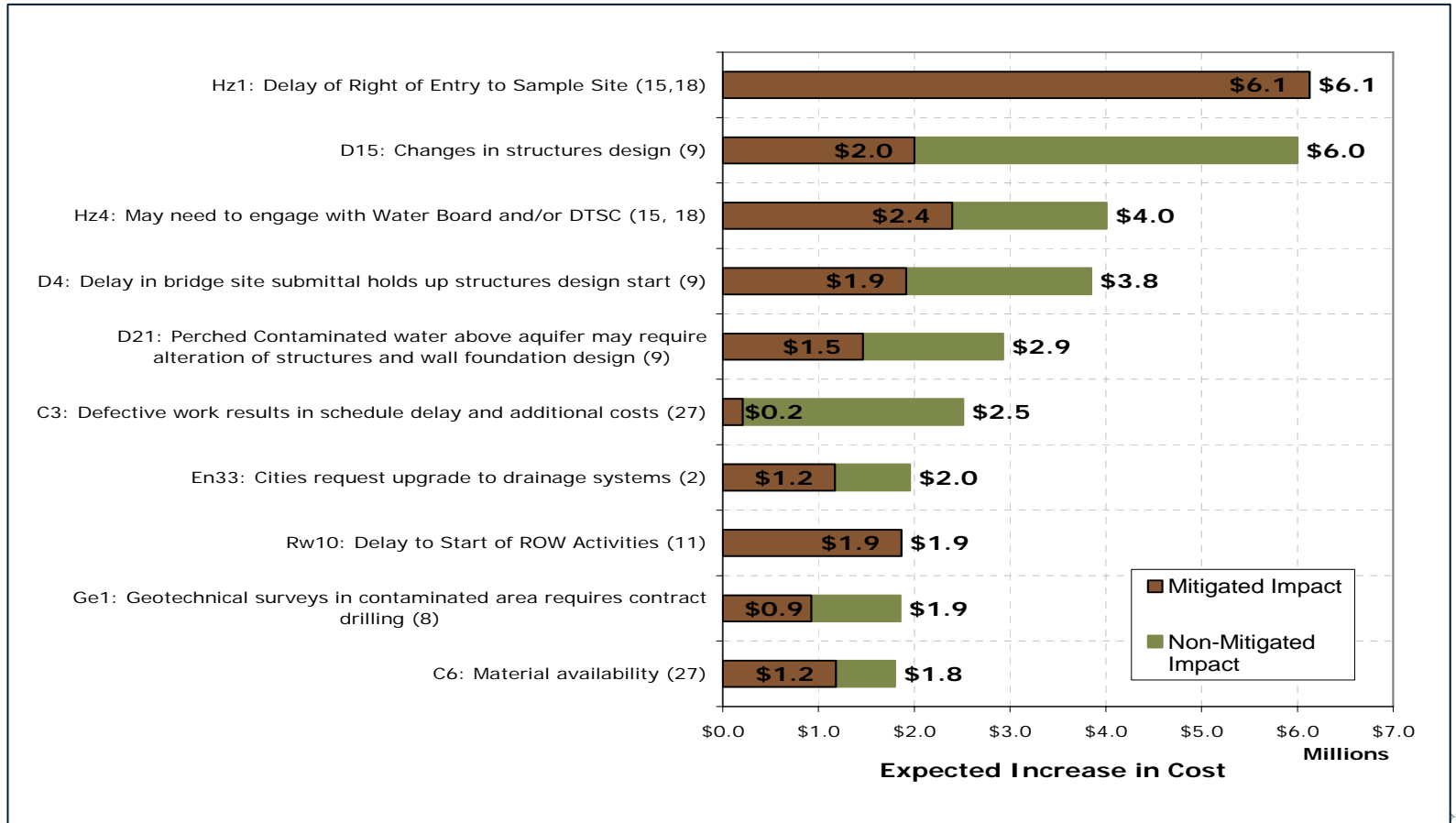
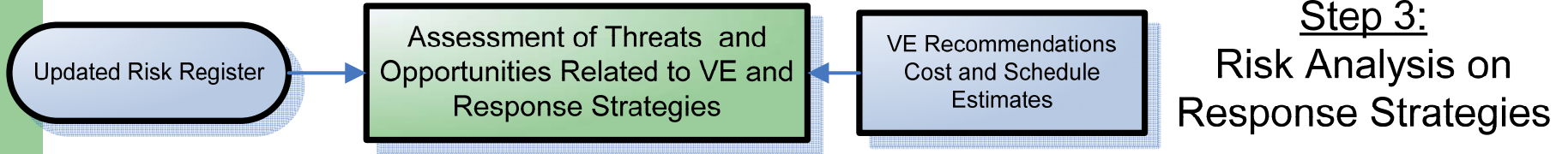
A	More Important
A/B	Equally Important

OVERALL PERFORMANCE		Performance (P)	% Change Performance	Cost (C)	% Change Cost	Value Index (P/C)	% Value Improvement
	Baseline	500		\$235.7		2.12	
1	Reduce Risk	529	6%	\$235.7	0.0%	2.24	6%
2	Cost Estimate	500	0%	\$165.7	29.7%	3.02	42%
3	Construction staging	562	12%	\$165.7	29.7%	3.39	60%
4	TH 14/15 I/C	612	22%	\$235.3	0.2%	2.60	23%
5	Median Barrier	606	21%	\$236.3	-0.2%	2.56	21%
6	Roadway between TH 15 & CSAH 37	562	12%	\$232.8	1.2%	2.41	14%
7	Courtland I/C	504	1%	\$233.0	1.2%	2.16	2%
8	Nicollet I/C	503	1%	\$234.8	0.4%	2.14	1%
9	561st Intersection	599	20%	\$235.5	0.1%	2.54	20%
10	Project phasing limits	511	2%	\$234.9	0.4%	2.18	3%
<b>Total</b>		<b>549</b>	<b>10%</b>	<b>\$158.0</b>	<b>33.0%</b>	<b>3.47</b>	<b>64%</b>



# CRAVE Process: Step 3

## Quantification Mitigation for Each Risk



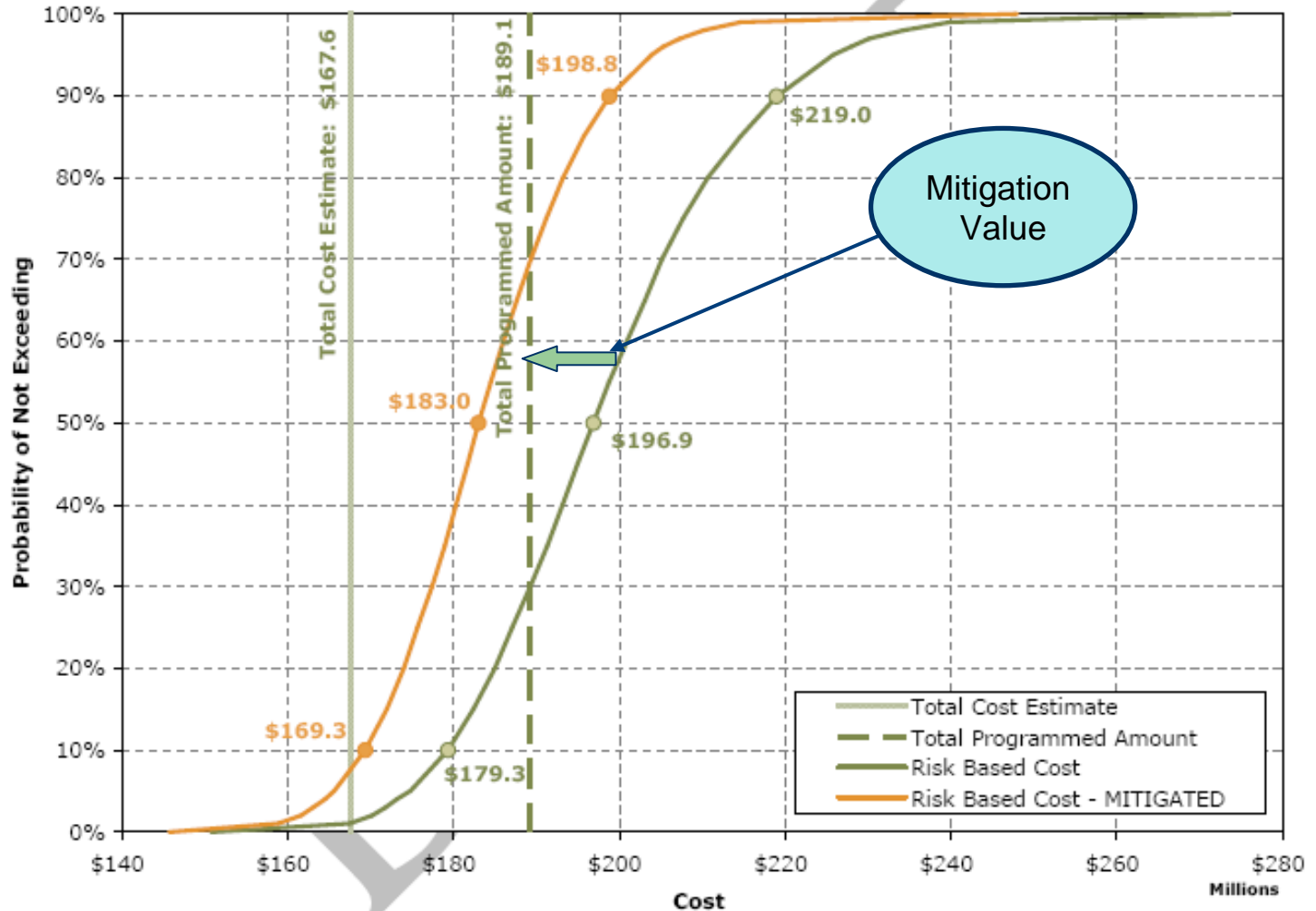
# Risk Responses

- ❑ **Avoidance** is a change to the project scope to eliminate the impact of a risk.
- ❑ **Transference** of a risk to another party who is more capable at handling the risk (such as the contractor or insurance company).
- ❑ **Mitigation** is seeking to lessen the impact of a specific risk items, which may involve the consumption of additional time and/or money.
- ❑ **Acceptance** is recognition by the project team of a specific risk and decision to not take action to deal with the risk.



# CRAVE Process: Step 3

## Quantifying Mitigation Strategies at the Project Level



# CRAVE Process: Step 4

## *Tracking, Monitoring, and Control*



*Avoiding Denial*



# CRAVE Process: Step 4

## Adequate and Continuous Reporting

**OCTOBER 2004**  
**EXECUTIVE SUMMARY - RISK REPORT**  
 Metropolitan Transportation Authority

Federal Transit Administration  
 Lower Manhattan Recovery Office

### South Ferry Project

**GENERAL**

**Summary:** Based on a risk assessment of the Grants & systems contract, the CRAVE team has identified a 20% probability that the \$400 M will be met or under run and a 20% probability that the Grants total cost estimate of \$400 M will be met or under run. There is a 50% probability of the cost being equal to or less than \$400 M. Based on a risk assessment of the Grants & systems contract, delays of up to nine months can be expected.

**Advisive Comments:** This Month Meetings were held with the Grants to follow the progress of the CRB structural box contract bids and negotiations.

**Advisive Comment for Next Month:** Upon receipt of the CRB contract's BAF bid cost and contract conditions, the CRAVE team will conduct a red-schedule risk assessment.

**COST**

**Top Five Risks and Mitigation Strategies**

- Construction Budget Risk:** MFACC based its cost estimate on an escalation of 2% APR. Recent history of construction in New York suggests a higher escalation rate. Escalation included in bid going for the structural box contract will be reviewed to refine the estimated escalation rate.
- Jointed Conals (Budget Risk):** This is a top risk based on the magnitude of the indirect costs and their potential variability.
- Quantity, Major Underpinning, Risk Escalation (Budget Risk):** MFACC did not provide quantity estimates in the CRB bid documents. MFACC has received and provided quantities to support the BAF Q process.
- Quantity, Major Underpinning, Risk Escalation (Budget Risk):** The proposals to support the CRB bid documents will establish productivity rates for contract bids for the CRB structural box. We establish productivity rates for these elements of the project.
- Quantity, Station Work, Risk Escalation (Budget Risk):** The use design work will define these program elements and associated costs with more certainty.

**SCHEDULE**

**Top Five Risks and Mitigation Strategies**

- Sequencing of work items and construction (PS&E):** MFACC is defining contracts work schedule to reduce conflicts between contractors.
- Sequencing of permits (PS&E):** MFACC attends monthly interagency coordination meetings to resolve permitting and other issues.
- CRB Q (Risk PS&E):** MFACC will provide a construction CRB Q plan.
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- CRB Q (Risk PS&E):** MFACC will provide a construction CRB Q plan.

**GRANTEE**

**Advisive Comment:** This Month

- The Grants received bids for the CRB structural box and has been working with the prospective contractors to develop a final contract price.

**Cost Contingency**

There is a 50% probability that the project cost will not exceed \$402 M. There is a 20% probability that the CRAVE total estimate of \$400 M will be met. It is recommended that FTA hold a reserve for the project.

**Schedule Contingency**

There is a 50% probability that the schedule will be met or better than 3 months. There is a less than 5% probability that the schedule will be met. This is due to MTA not including float on the critical path. MTA faces typical construction risks on the project.

**Outstanding Issues**

The source of funding for the additional cost above the MFACC's current \$400 M budget needs to be identified.

The risk analysis for this project will be completed after the final terms and price are determined for the CRB structural box contract.

**DRAFT**

Page 1 of 3

**I-5 Grand Mound to Maytown Widening Project**  
 March-April 2006

**Scenario**  
 N/A

**Project Description:**

- Adds two lanes to I-5 between the Maytown and Grand Mound interchanges.
- Realigns and flattens I-5 mainline.
- Improves Grand Mound interchanges to accommodate I-5 widening and enhance safety.
- Adds two lanes, bike lanes and sidewalks to US-12.
- Improves various access and exit ramps/points.
- Replaces Prairie Creek bridges.
- Replaces bridges over Scatter Creek.
- Provides storm water treatment ponds.
- Connects rest areas to the Thurston County Sanitary sewer system.

**Schedule:**

Begin Construction  
 80% Range:  
 Jan-08 to Apr-08

End Construction  
 80% Range:  
 Jul-10 to Jul-11

**CRA Results:**

**Project Benefits:**

- Improves traffic flows and LOS along I-5.
- Enhance safety along I-5 mainline.
- Enhances safety and improves traffic flows at I-5 access and exit points.
- Improves operation and safety of Grand Mound interchange.
- Improves traffic flows and safety, and promotes alternative mode use on US-12.

**Project Cost Range:**

10% chance the cost < **\$94.0** million

50% chance the cost < **\$97.3** million

90% chance the cost < **\$101.8** million

**Project Risks:**

- Fish window constrains bridge removal work schedule.
- NEPA decision made three years ago.
- Uncertainty in the environmental permitting process (e.g., wetland mitigation).
- Unsuitable foundation excavation and fill costs (additional costs due to wet-season work or unsuitable areas).
- Fish habitat and passage issues (numerous culverts requiring replacement or lengthening).
- Coordination challenges.
- Design deviations unapproved.
- Unknown cultural resources discovered during construction.

**What's Changed Since 2002 ScORE Workshop:**

- Storm water treatment and erosion control BMP's
- Bridges now replaced rather than widened

**Financial Fine Print (Key Assumptions):**

- Inflation escalation for project construction ranges from 1.30% to 3.10%; costs are escalated to mid-point of construction.
- Project costs include about \$6 million of (non-quantified) other miscellaneous items.
- Rest area improvement costs are not included in total project costs.

**Level of Project Design:** Low Medium High

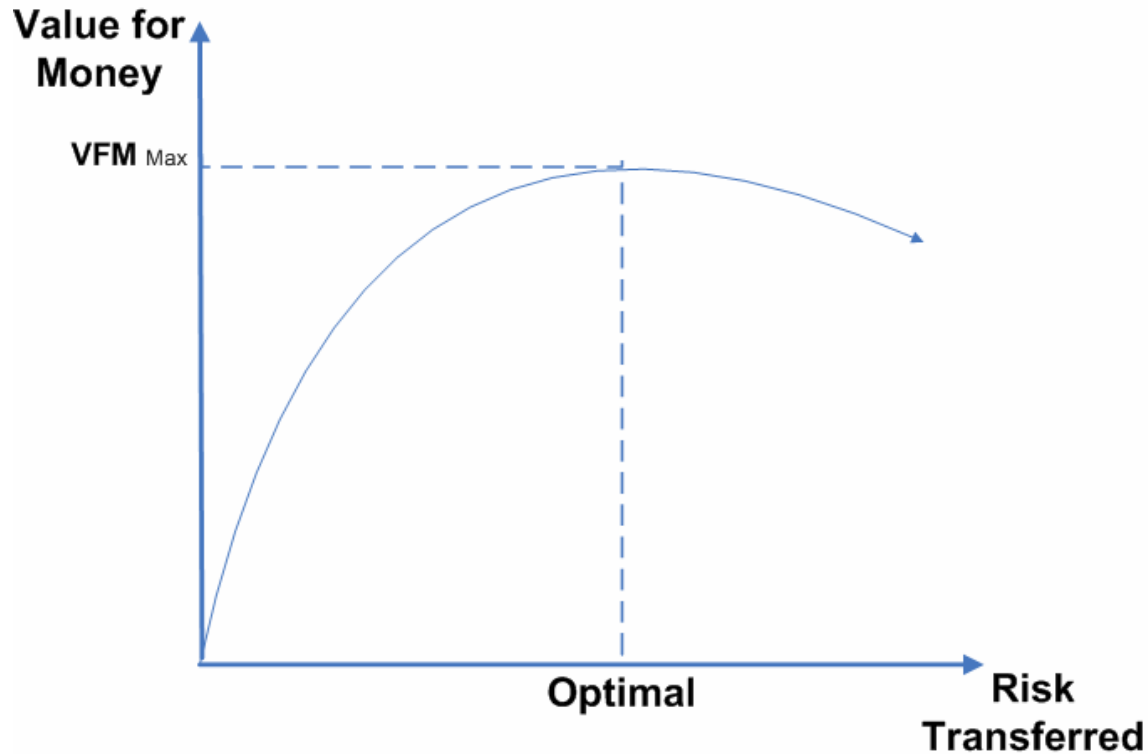
April 20, 2006

Washington State Department of Transportation

Transparency and accountability



# CRAVE Process: Step 4 Informed Risk Allocation



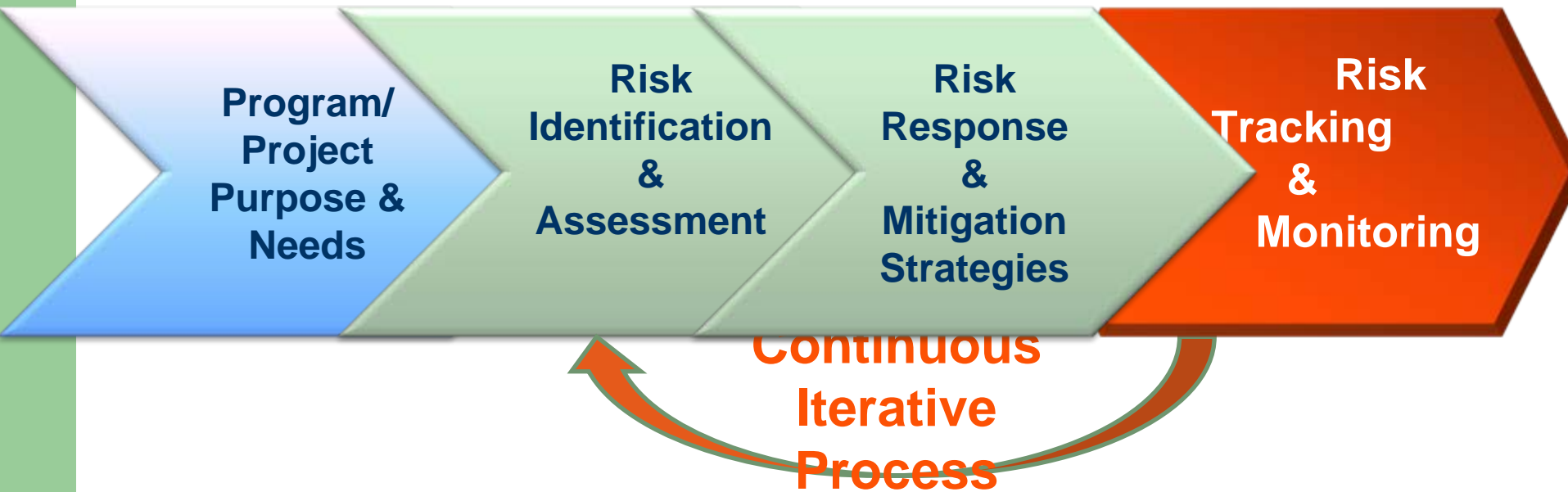
Contractors  
do not take  
risks

**They Price it !**



# Defining Risk Management

Risk Management is the systematic process of identifying, assessing, and responding to risks in order to manage or reduce potential adverse effects on the achievement of program and project goals



# Managing Threats and Opportunities

The image displays two overlapping windows from the Risk Management System. The background window shows a risk matrix and various input fields. The foreground window is the main menu for the SR 520 Bridge Replacement and HOV Program.

**Risk Matrix (Background Window):**

Probability	VL	L	M	H	VH
VH	Green	Yellow	Red	Red	Red
H	Green	Green	Yellow	Red	Red
M	Green	Green	Yellow	Red	Red
L	Green	Green	Yellow	Red	Red
VL	Green	Green	Green	Yellow	Red

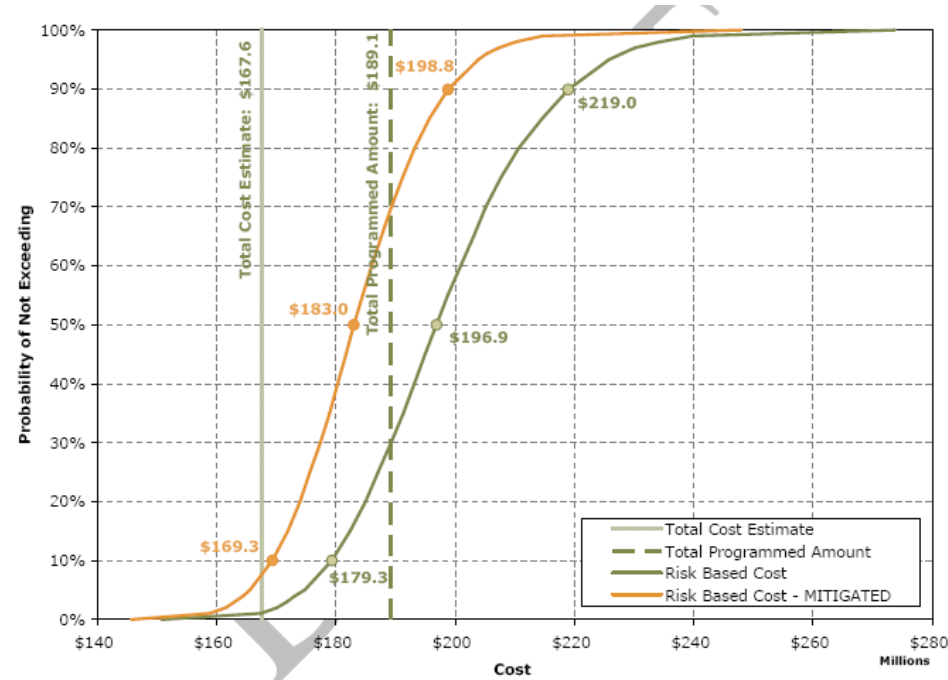
**Main Menu (Foreground Window):**

Washington State Department of Transportation  
**SR 520 Bridge Replacement and HOV Program**

- Data Entry
  - Projects
- Manage Top 20 Risks
  - Cost
  - Schedule
- Admin
- Reports and Charts
  - Project Reports
  - Cost EV Tornado
  - Schedule EV Tornado
  - Master Project Flowcharts
- Export to Excel
  - Export to Excel RMP Style
  - Export to Excel Single Line Style
- Import Risk from Excel
  - Import From Single Line Risk Register
  - Import From RMP Format
- Exit

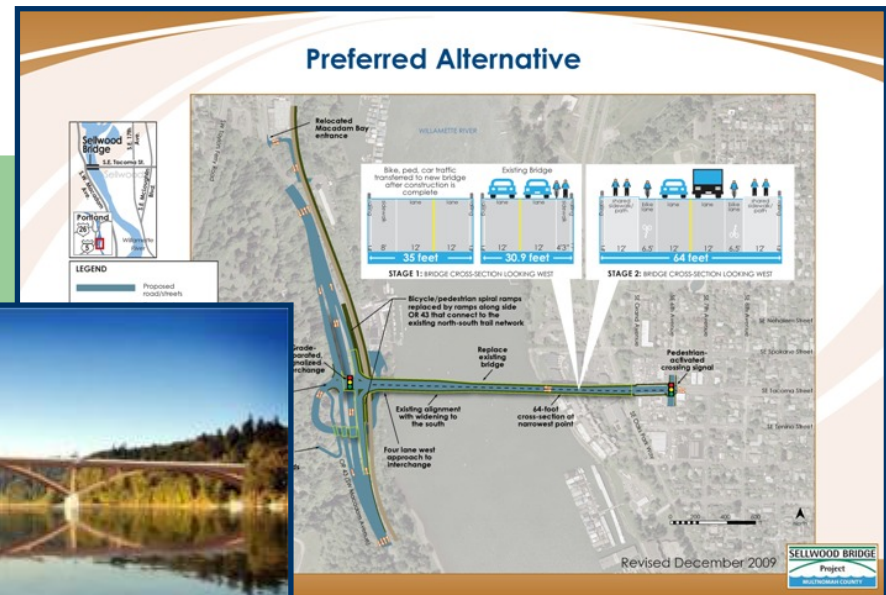
*Risk Management System*

# CRAVE



## *Sellwood Bridge Project*

### *CRAVE*

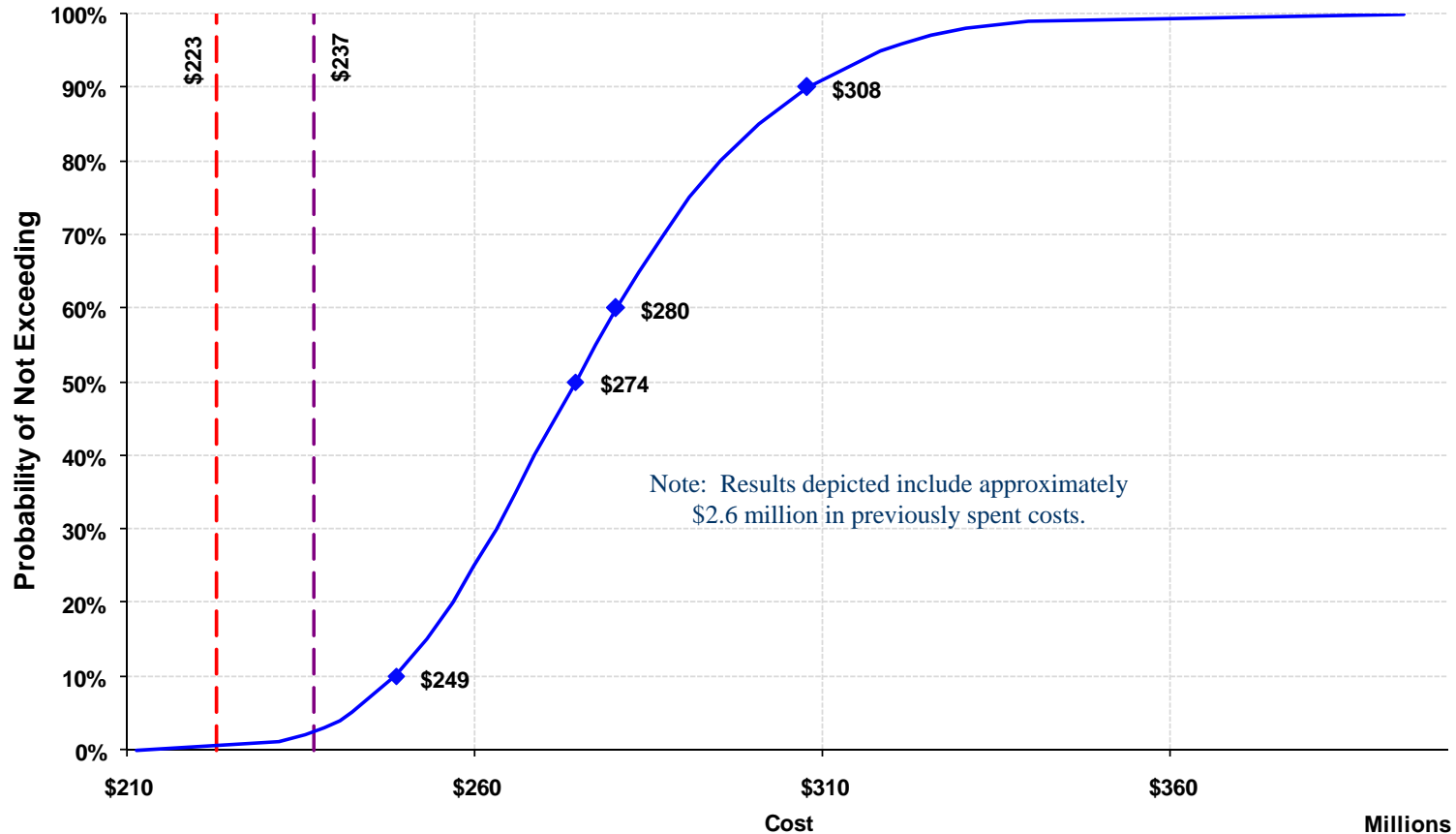


April 26, 2011



# Probabilistic Cost Curves – Total Project Cost

## Risk Analysis Results Total Project Cost

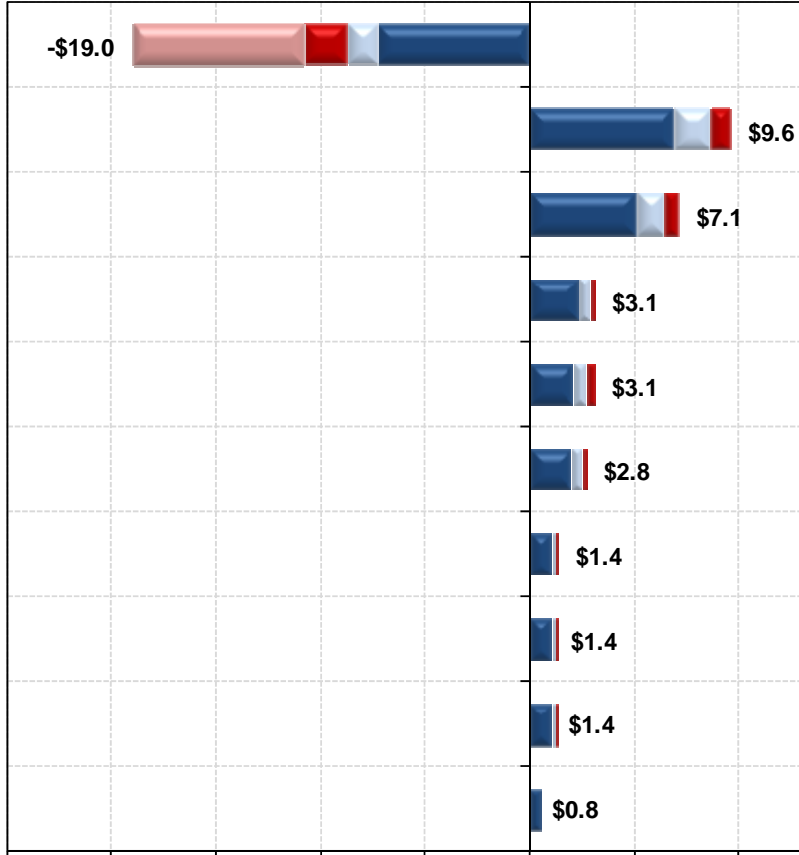


- Base Cost Estimate (Current Year \$'s)
- Base Cost Estimate Escalated w/Base Schedule (YOE \$'s)
- Risk Analysis Results (YOE \$'s)

# Tornado Chart – Top Risks Impacting Project Costs

**Top Cost Risks**

- SF-1: Opportunity of a shoo-fly alignment (Split Evenly between 20,23)
- CON-22: Extraordinary steel price escalation (20,23)
- CON-16: Shortage of DMWESB (All Construction activities)
- CON-23: Landslide triggered during excavation in interchange area (14,16)
- DES-3: Add scope to the project for North-South Streetcar Project (21)
- CON-19: Meeting Sustainability Goals (All Construction activities)
- CON-14: Other Construction Projects in Region Limit Supply / Cost of Materials (Impact to Non-Steel Materials) (All Construction activities)
- STG-2: Changing Geotechnical Conditions (Due to New Information) Landslide (18)
- STG-3: Stabilize entire landslide (not just bridge) (18)
- DES-6: Design features are added to the bridge (20,23)



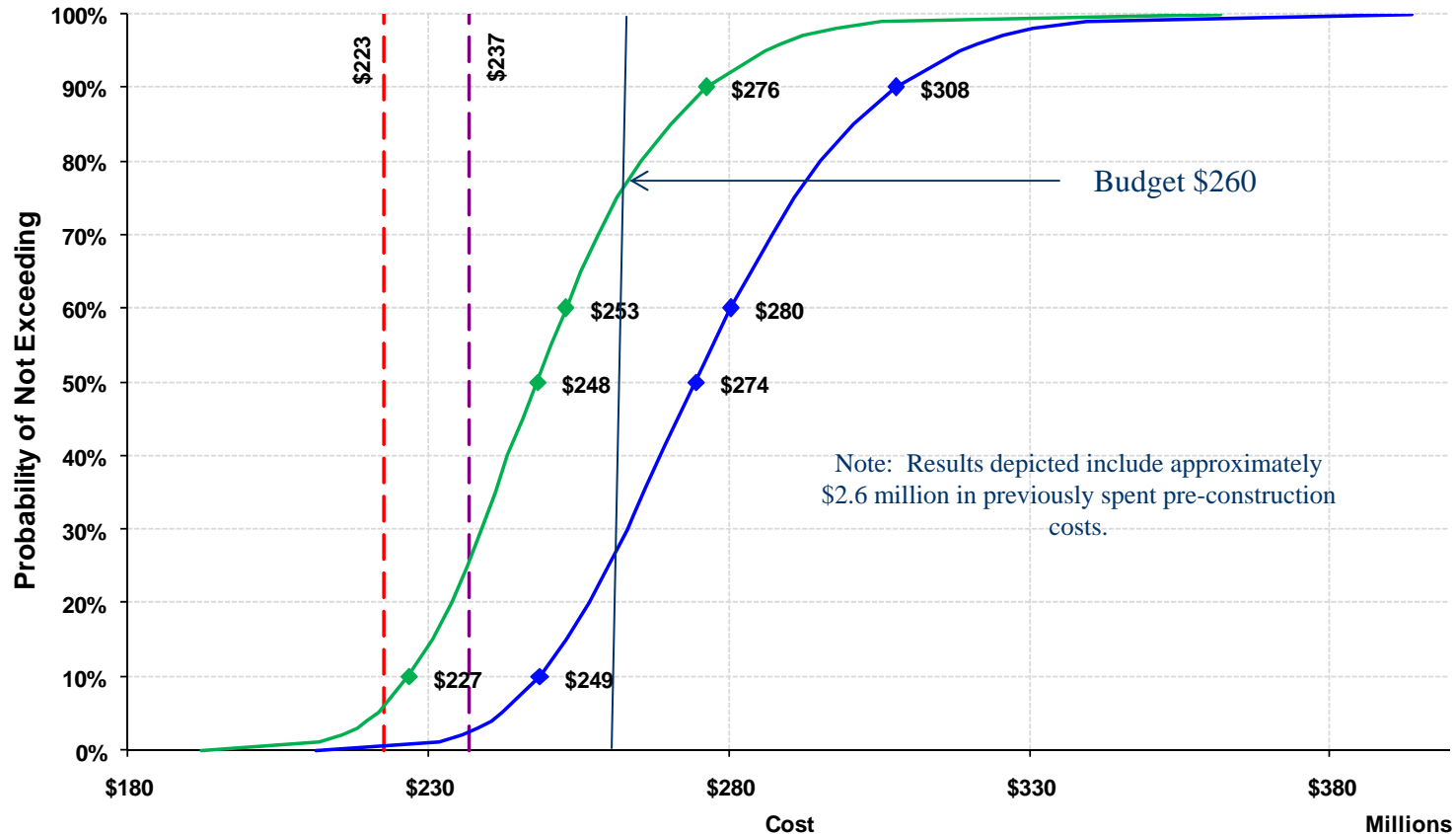
■ Event Risk Cost	■ Event Risk Cost Markup
■ Escalation Cost	■ Additional Support Cost

-\$25    -\$20    -\$15    -\$10    -\$5    \$0    \$5    \$10  
 Millions  
 Expected Value (Mean) Increase in Overall Project Cost



# Probabilistic Cost Curves – Project Total Cost

## Risk Analysis Results Total Project Cost



Note: Results depicted include approximately \$2.6 million in previously spent pre-construction costs.

- Base Cost Estimate (Current Year \$'s)
- Base Cost Estimate Escalated w/Base Schedule (YOE \$'s)
- Pre-Response Cost - Risk Analysis Results (YOE \$'s)
- Post-Response Cost - Risk Analysis Results (YOE \$'s)

# Value Engineering Study

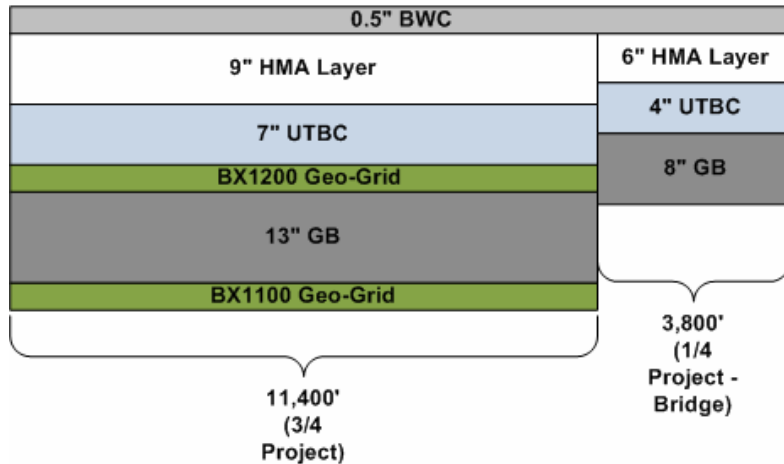


*SR 193  
Extension  
2000 West  
to I-15*



# Recommendation #10 Pavement Type

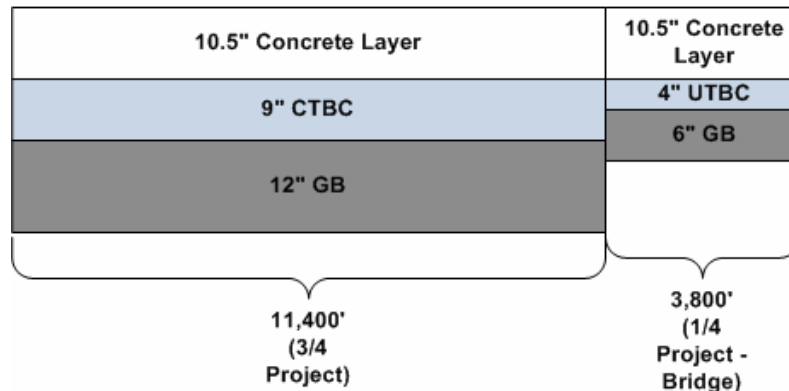
Asphalt Option with Geo-Grid  
(Does Work)



$$Value = \frac{Performance}{Cost}$$

$$HMA \quad \frac{500}{8.7} = 57.5$$

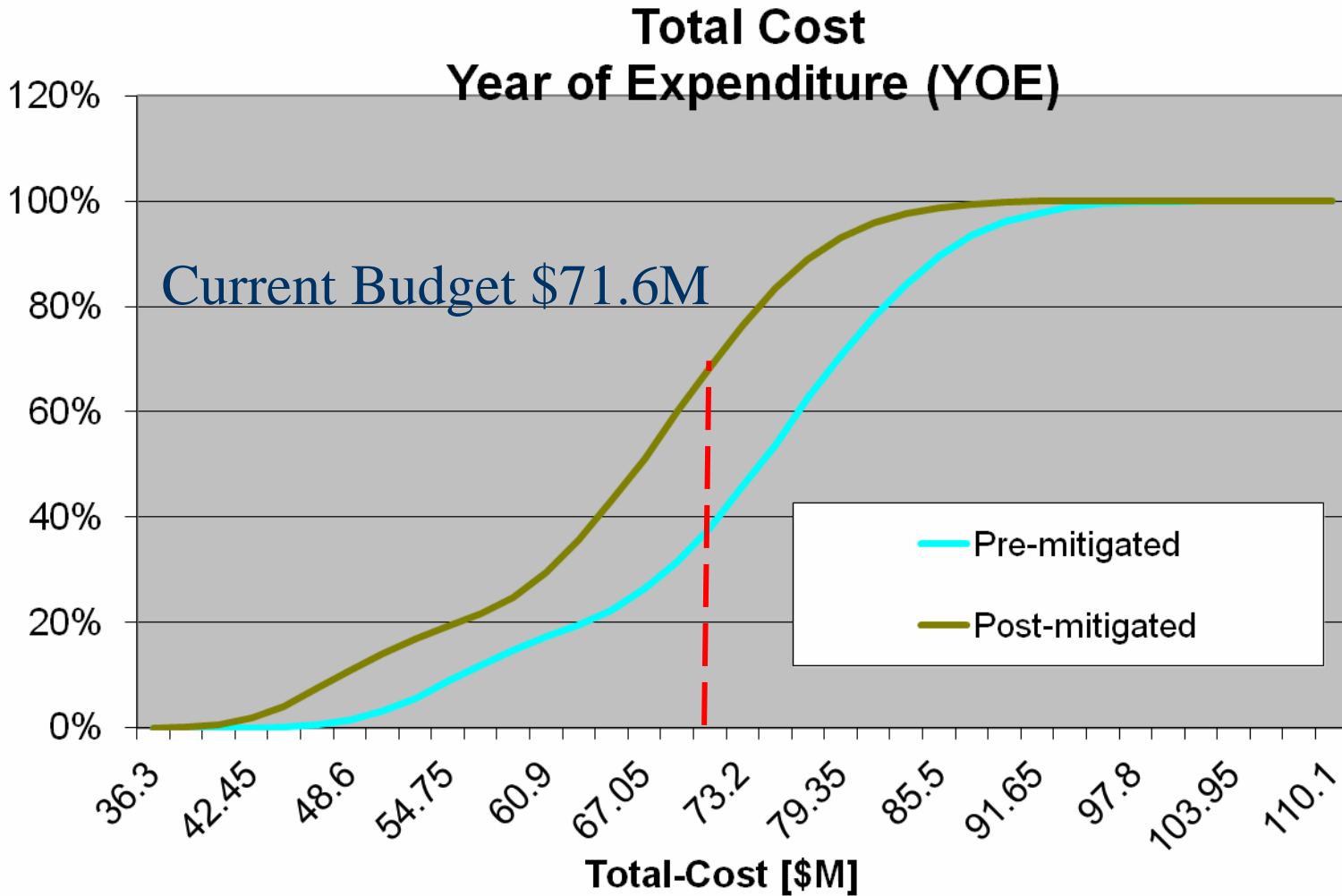
Concrete Pavement



$$PCCP \quad \frac{683}{10.3} = 61.9$$

PCCP is a 8% improvement  
in value

# Post Response Cost Risk



# CRAVE™ Results

**40 Year pavement  
with a better than  
65% chance of not  
exceeding current  
budget**

Statistics	Pre-mitigated	Post-mitigated
Min	41.91 \$M	38.15 \$M
Max	101.93 \$M	95.47 \$M
Median	73.44 \$M	67.87 \$M
10%	55.02 \$M	49.10 \$M
20%	61.95 \$M	56.24 \$M
30%	67.62 \$M	62.09 \$M
40%	70.84 \$M	65.22 \$M
50%	73.44 \$M	67.87 \$M
60%	75.93 \$M	70.10 \$M
70%	78.50 \$M	72.55 \$M
80%	81.26 \$M	75.22 \$M
90%	85.08 \$M	78.72 \$M

# Contact Information



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## **Additional HDR Certified Value Specialist**

- Tammy Dow, M.SC.E., P.ENG., CVS
- Blane Long, CVS
- Don Owings, PE, CVS