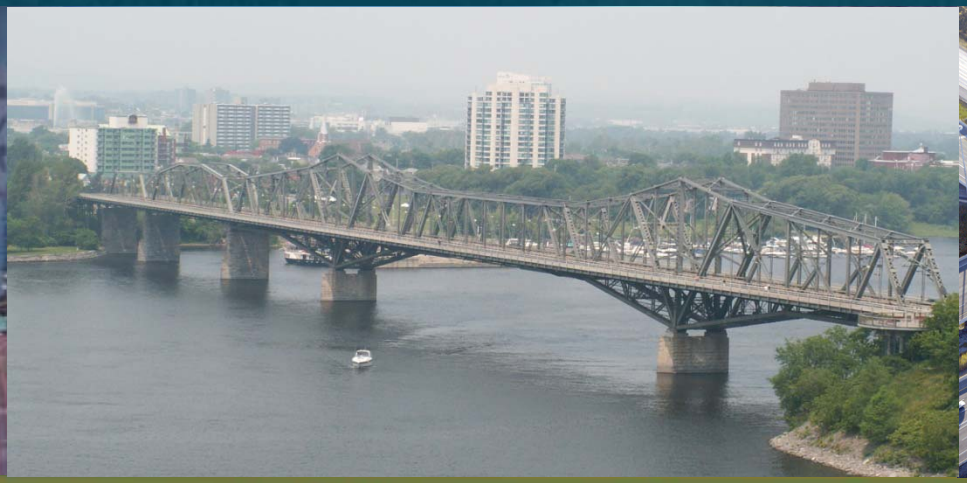
CRA~VE


An Integrated Process for Cost Risk Analysis and Value Engineering

November 23 & 24, 2009

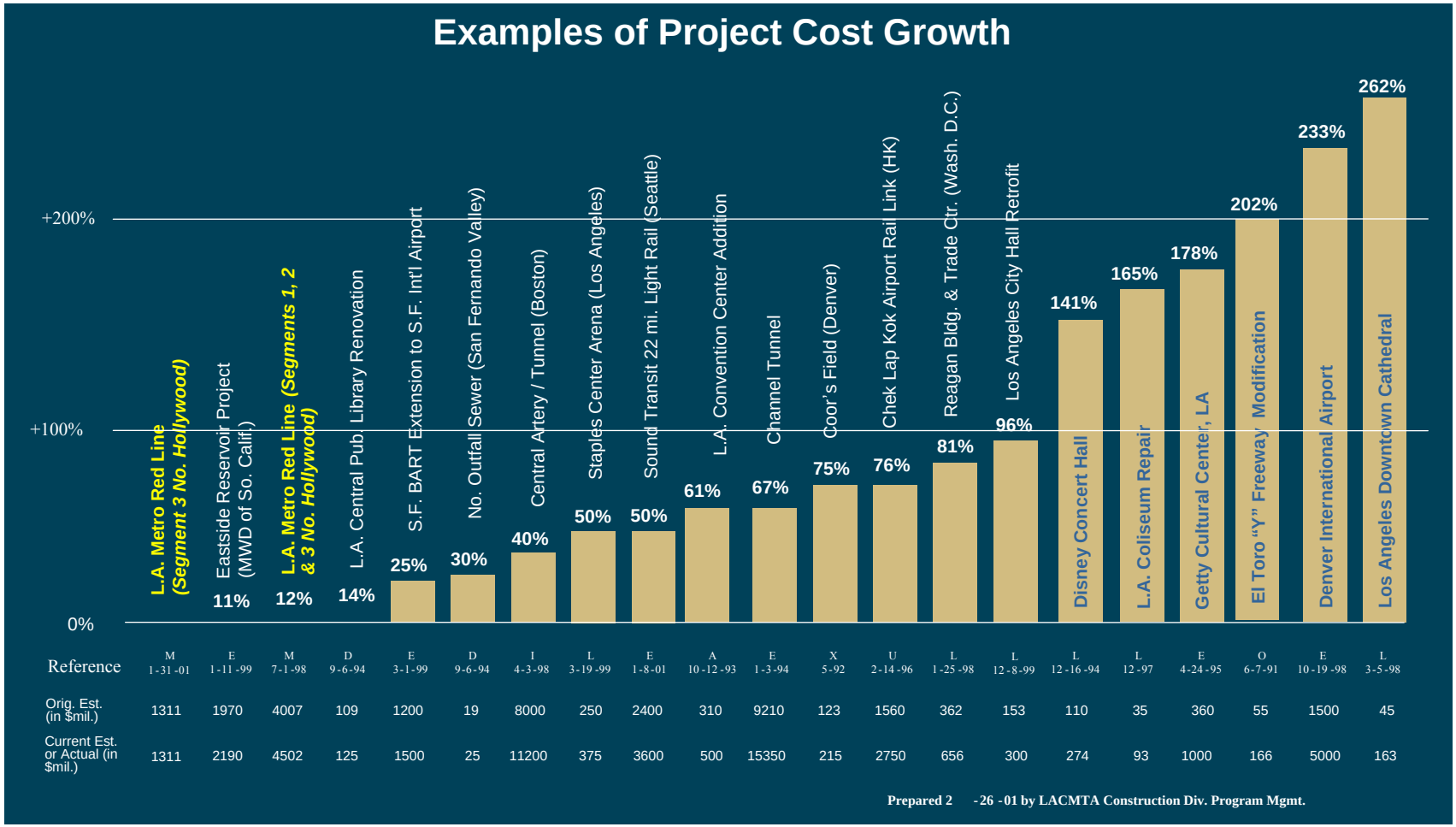
HDR

Agenda

- Why Risk Management?
- What is CRA~VE?
- CRA~VE Steps:
  1. Baseline Risk Assessment
  2. Value Engineering and Risk Response
  3. Risk Analysis on Risk Response Strategies
  4. Tracking, Monitoring and Control
- HDR and Risk Assessment

Overruns are a Reality!

- Over 40% of all infrastructure projects, and over 80% of major infrastructure, exceed their budget or schedule



New Realities

- With the current financial turmoil, funding constraints, volatile commodity prices, and policy/regulation changes, conventional planning methods are no longer sufficient
- Credible, transparent, and comprehensive processes become critical for effective infrastructure planning
- Credibility means that decision-makers must know the nature and magnitude of risks to determine their risk tolerance so that they make effective decisions

Why Risk Management?

- Encourages being proactive and early planning
- Builds confidence and credibility in project's plans and estimates
- Helps to develop targeted mitigation strategies for all anticipated threats
- Better allocation of risks and identification of project delivery methods
- Ensures transparency, integrity, and accountability throughout the life-cycle of the project

Maximizes the Likelihood of Meeting On-Time & On-Budget Goals

What is CRA~VE?

- Integrated process of Cost Risk Analysis & Value Engineering which identifies and quantifies opportunities while accounting for risk
- CRA~VE involves the combination of process and tool for the project team to:
  - Compare all possible alternatives and solutions suggested or recommended by the value engineering team
  - Select the best alternative/solution
  - Generate better project cost and schedule forecasts for budgeting and bonding
  - Obtain a quantified risk management plan for project planning
  - Minimize overall project costs and risks
  - Provide a reality check on proposed innovations

Cost Risk Analysis Principles

IDENTIFY and VALIDATE RISKS

Avoid false precision; as big a problem as early optimism "Approximately right is better than precisely wrong"

QUANTIFY and COMMUNICATE RISKS

Relate "contingency" to everyday experiences with uncertainty

MITIGATE RISKS

Invest in continuous and transparent QA/QC of actual cost estimating process

Traditional vs. Risk-Based Estimation

Fixed Contingency %

Project Deterministic Estimate

Project Base Cost

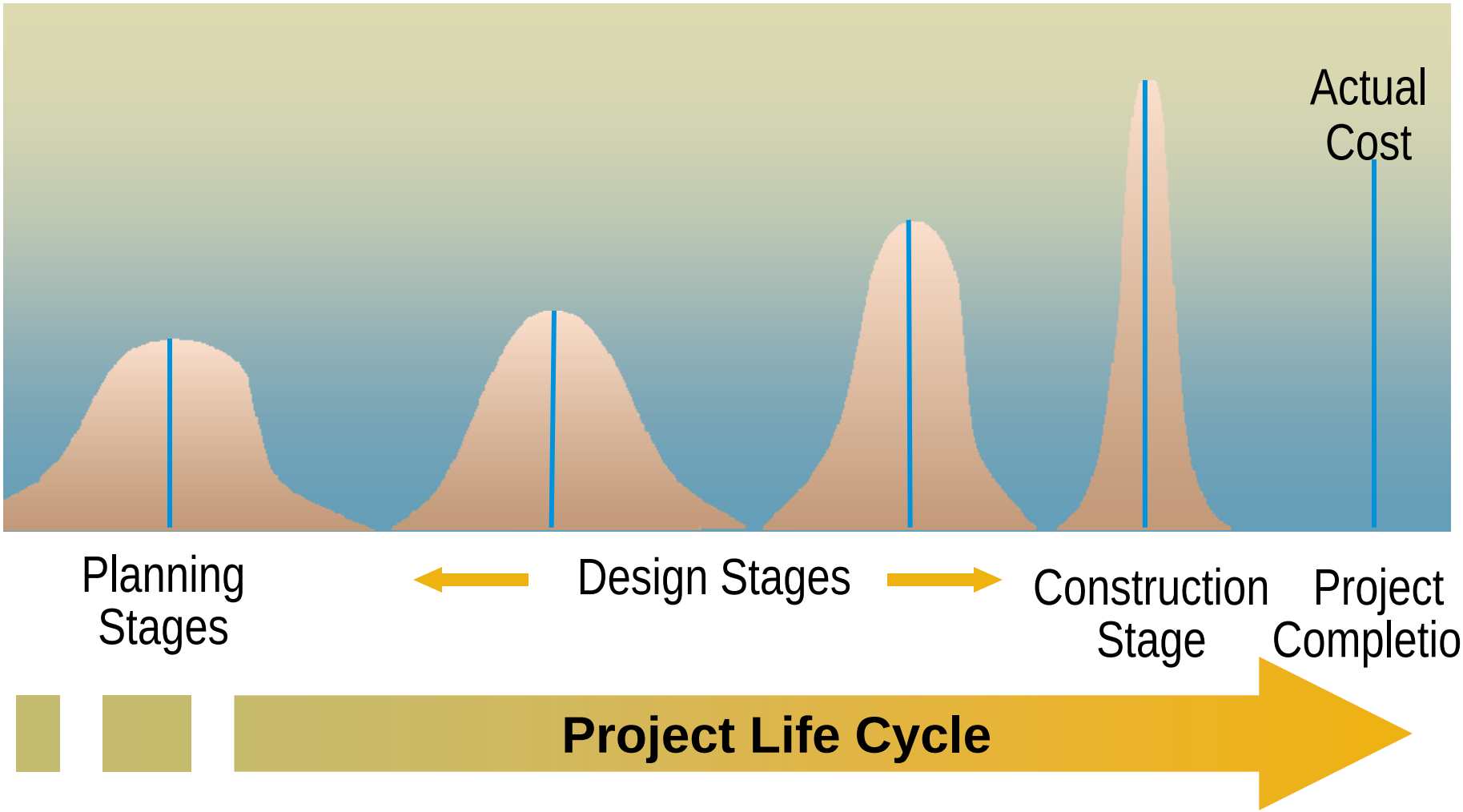
Geotech 20%

Materials 40%

Environmental Requirements 30%

5% Design

Uncertainty and Project Delivery



CRA~VE Process - Key Steps

Step 1: Baseline Risk Assessment

- Review Baseline Cost and Schedule
- Identify and Quantify Risks Related to Baseline

Step 2: Value Engineering & Risk Response

- Develop VE Recommendations to Mitigate/Avoid High Risks
- Develop Recommendations that Add Value

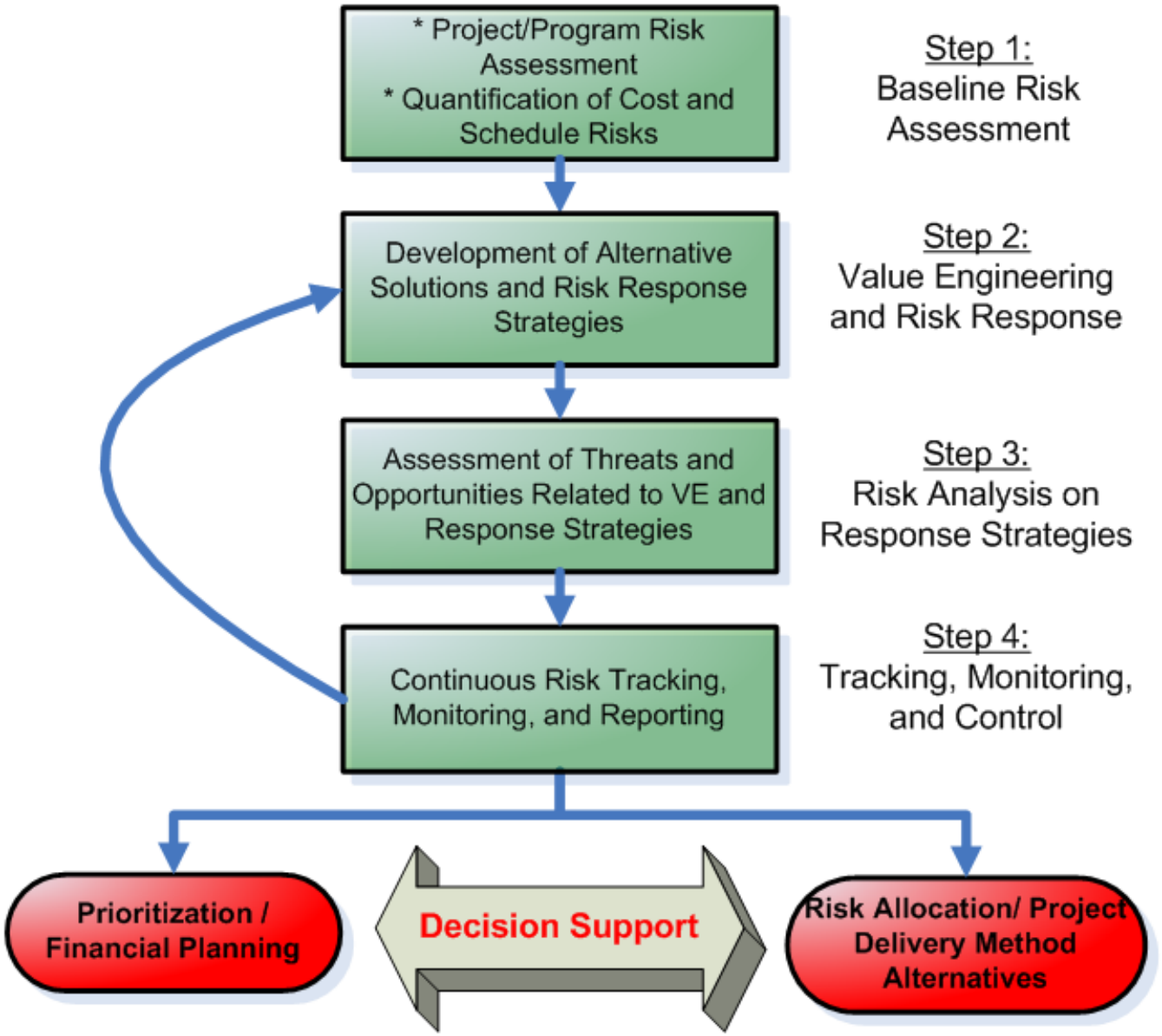
Step 3: Risk Analysis on Response Strategies

- Identify Risks Associated With Response Strategies
- Quantify Threats and Opportunities

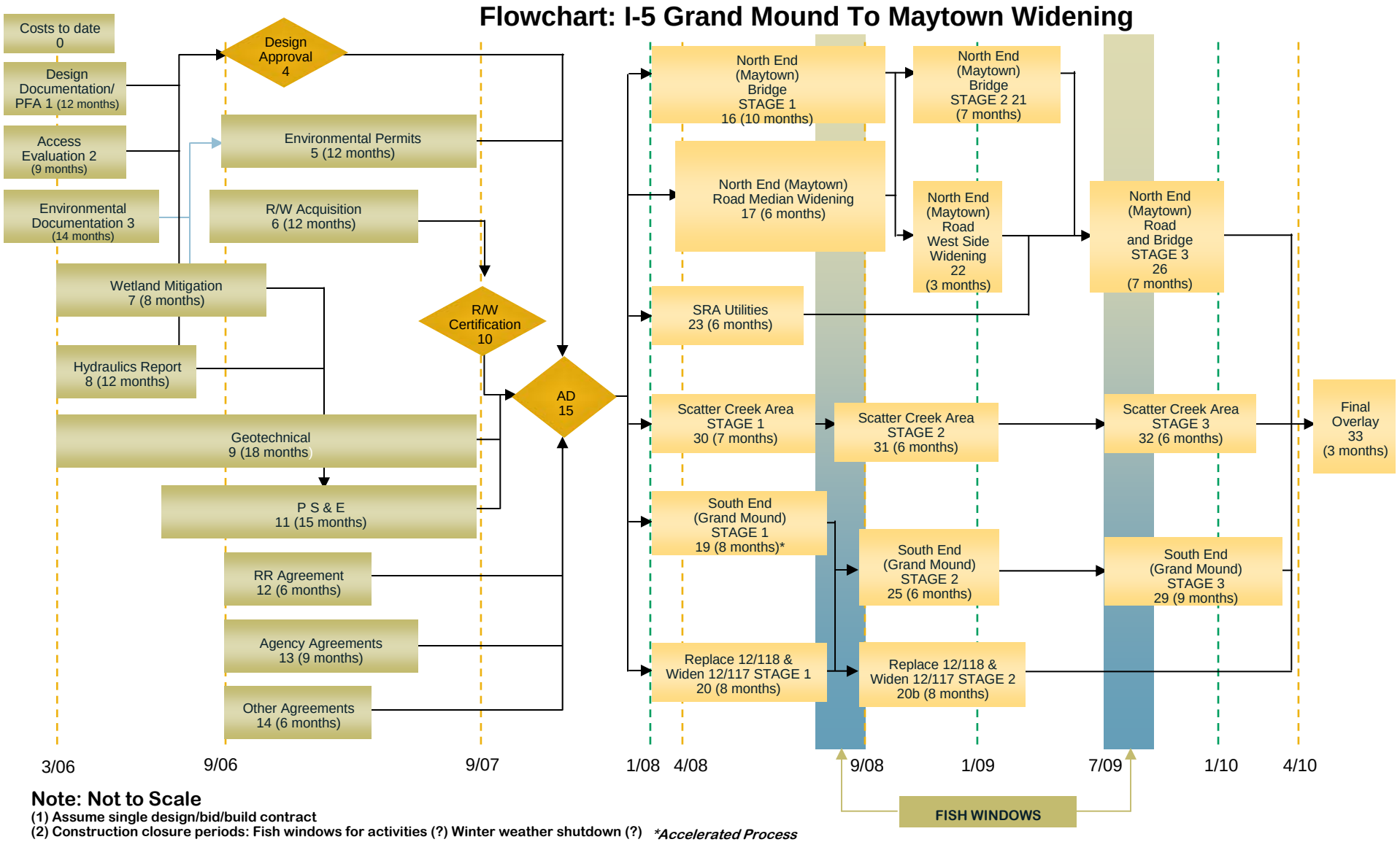
Step 4: Tracking, Monitoring, and Control

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

CRA~VE Analytical Process



Step 1: Baseline Risk Assessment
Review Baseline Schedule & Cost

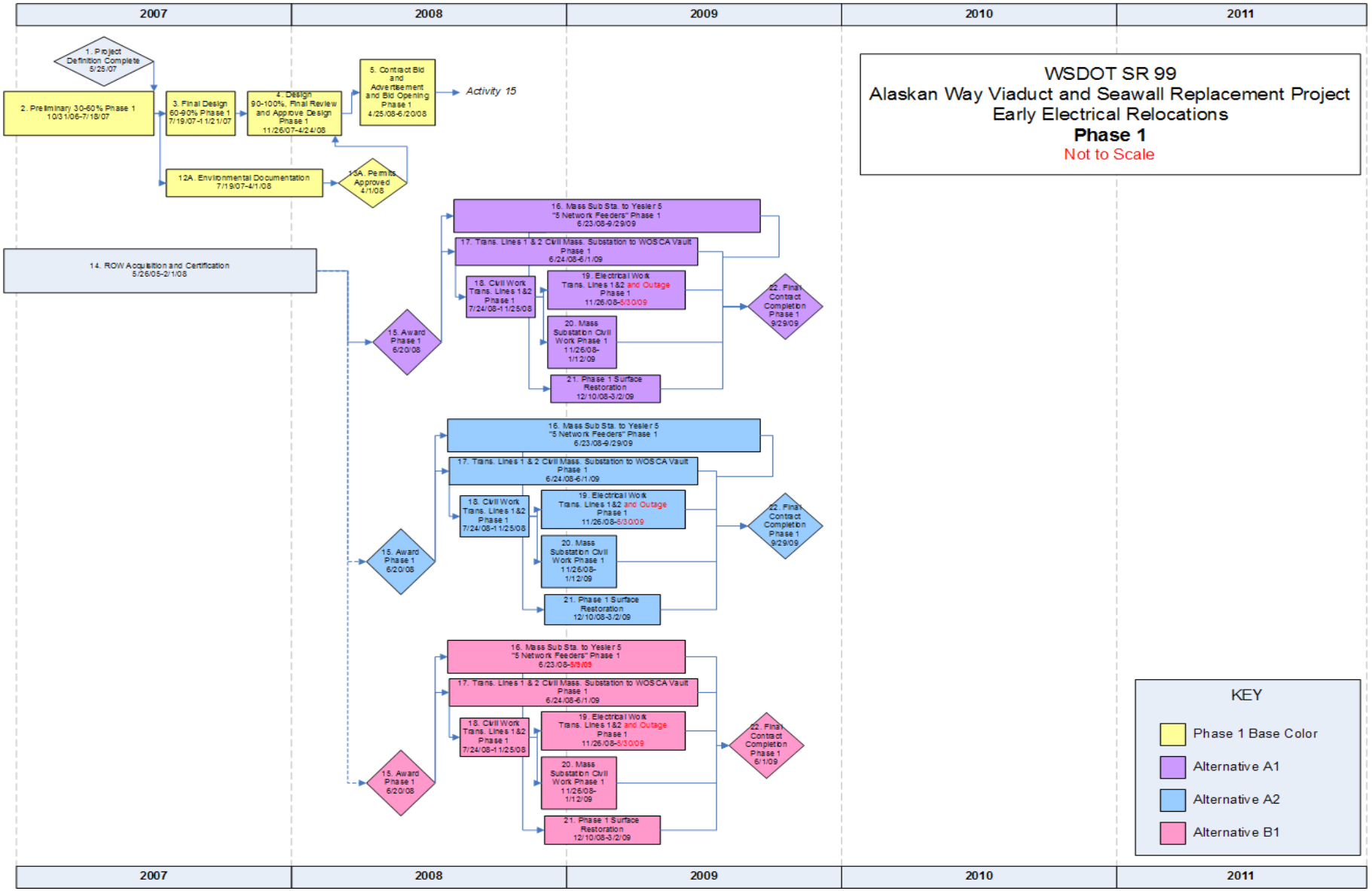


Note: Not to Scale

(1) Assume single design/bid/build contract

(2) Construction closure periods: Fish windows for activities (?) Winter weather shutdown (?) ***Accelerated Process***

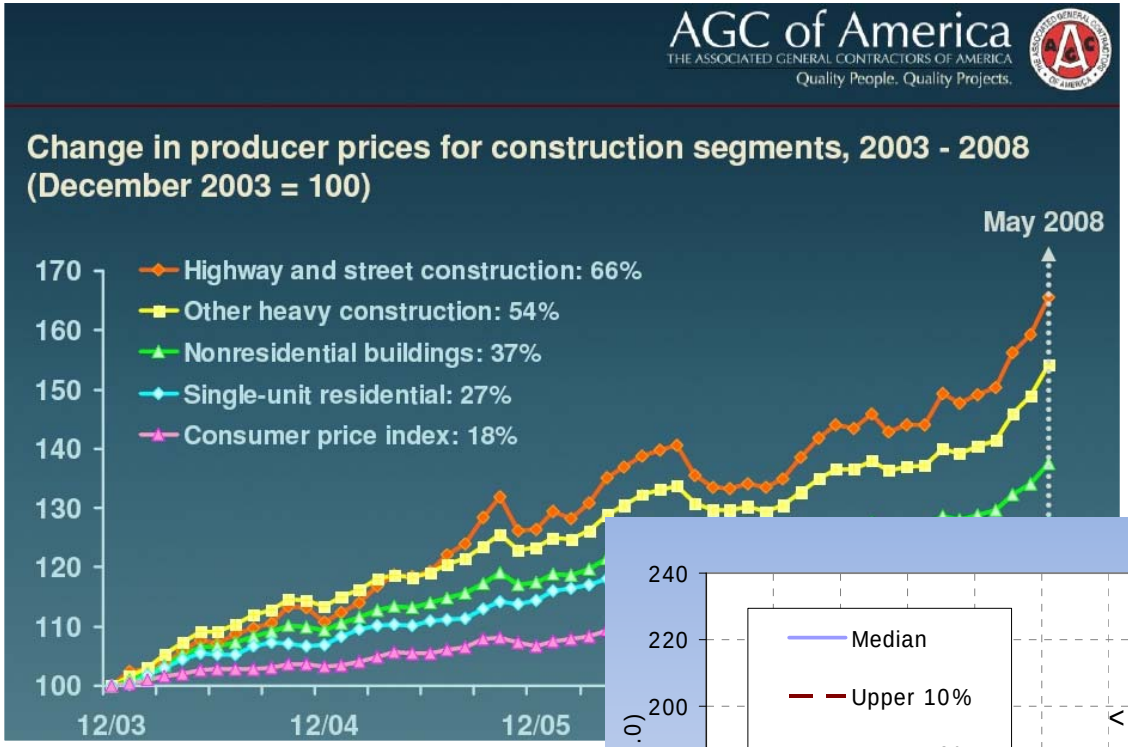
Step 1: Baseline Risk Assessment
Integrating CRA and VE



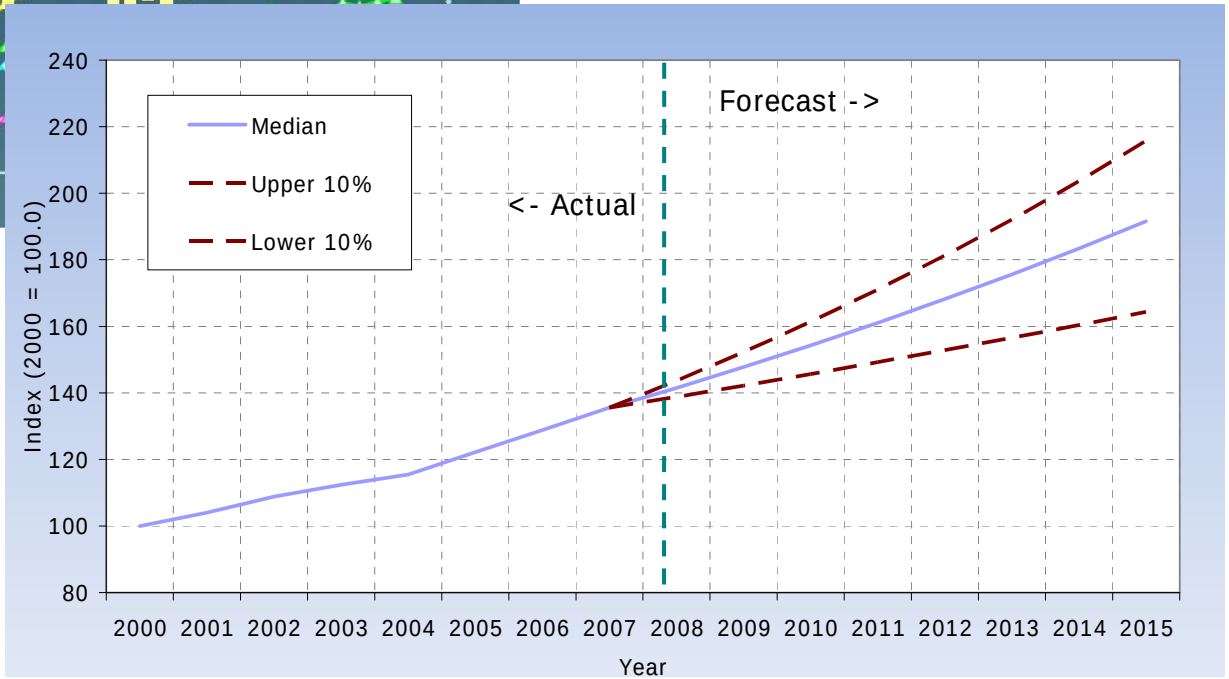
Step 1: Baseline Risk Assessment
Risk Categories

- Budget Risk:
  - Risk that budget elements will deviate from the estimate
  - Examples: material price escalation, limited competition, labor shortage
- Event Risk:
  - Risk of internal or external events that force the project team to work beyond the estimate just to meet the Project Scope and Statement of Work.
  - Examples: Environmental challenges, unforeseen subsurface conditions, extreme weather, public pressure, public resistance
- Scope Risk:
  - Risk of significant changes to project scope due to external pressures.
  - Examples: stakeholder pressure for a grander facility than the budget accommodates, additions to meet permitting agency demands

Step 1: Baseline Risk Assessment
Deriving Project-Specific Budget Escalation



Project-Specific Escalation



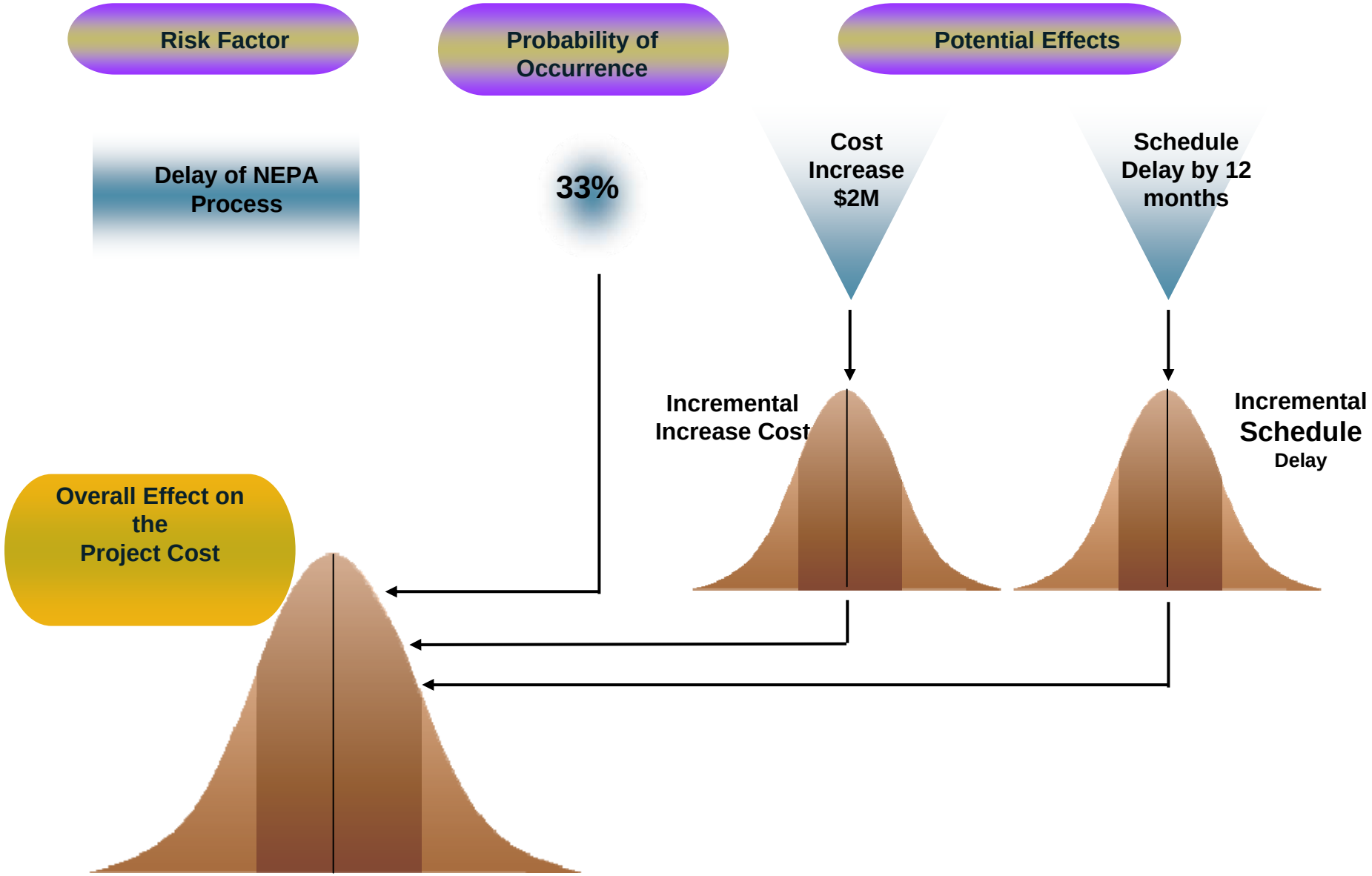
Step 1: Baseline Risk Assessment
Examples of Event and Scope Risks

- Environmental Risks
- Hazmat
- Utilities Risks
- Drainage Risks
- Traffic Management
- Market Conditions Risks
- Procurement Risks
- Right of Way Risks
- Performance Standards
- Financial Risks
- Natural Disasters
- Etc.

Step 1: Baseline Risk Assessment
Risk Analysis Workshop - Consensus Based Forum

- Review and validate cost & schedule estimates
- Identify and quantify potential risks
- Develop mitigation strategies
- Expert panel consists of project team leads representing expertise such as:
  - Environmental
  - Right of Way
  - Geotechnical
  - Utilities
  - Construction
  - Political and Public Relations
  - Etc.

Step 1: Baseline Risk Assessment
Quantifying Individual Risks

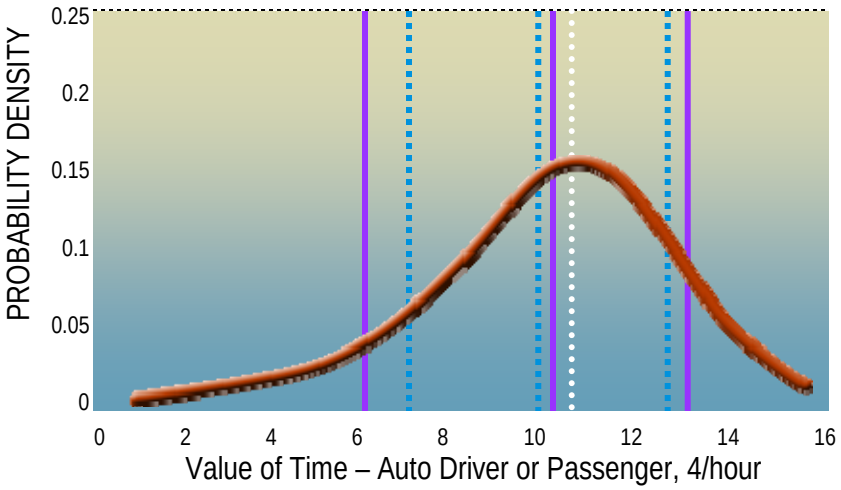


Step 1: Baseline Risk Assessment
Establishing Ranges for All Key Input Variables

Labour Rate ($/Hour)

Median	10% Lower	10% Upper
$50	$45	$75

80% Confidence Interval



Step 1: Baseline Risk Assessment
Identify, Quantify and Mitigate…

Activity Impacted	Identitfication					
	Risk ID	Functional Assignment	Threat / Opportunity Events	Additional Description	Panelists Comments	Type of Risk
c3	c4	c5	c7	c8	c9	c10
29	DES1a	Design, Permitting, Reviews, etc.	Lack of project support by SAM, Corp, Commission RMM & Site Demo	Impacts all design activities. Cost impact based on $350K per month.	High probability due to impending decision on project developer.	Cost & Schedule
33	DES1b					
11, 13	DES1c					

Quantitative Analysis

Prob.	Cost Impact ($)				Schedule Impact (Months)			
	Distribution	V1	V2 (L)	V3 (H)	Distribution	V1	V2 (L)	V3 (H)
c11	c12	c13	c14	c15	c19	c20	c21	c22
50%	Discrete		$500,000	$2,000,000	Uniform		6.0	12.0

Response			Mitigated Cost Impacts			Mitigated Schedule Impacts		
Strategy	Response Actions including Advantages & Disadvantages	Mtgtd Prob.	V1	V2 (L)	V3 (H)	V1	V2 (L)	V3 (H)
c26	c27	c29	c30	c31	c32	c33	c34	c35
Transference	Business case disclosure; allocation of benefits and costs (Public Private Partnership). Memorandum. Goal is to develop a better partnership with the rental car companies and help project move forward	5%	$0			1.0		
Mitigation	Business case disclosure; allocation of benefits and costs (Public Private Partnership). Memorandum. Goal is to develop a better partnership with the rental car companies and help project move forward.	25%		$500,000	$2,000,000		6.0	12.0
Acceptance	Business case disclosure; allocation of benefits and costs (Public Private Partnership). Memorandum. Goal is to develop a better partnership with the rental car companies and help project move forward.	25%		$500,000	$2,000,000		6.0	12.0

Step 1: Baseline Risk Assessment
Risk Register: Risk Identification

Activities Impacted	ID	Functional Assignment	Threat / Opportunity Events	Type of Risk	SMART Column	Additional Panelists' Comments
20	C1	Construction	Force Majure	Schedule	Major delays from storms, earthquakes or other unavoidable natural disasters	
13	D1	Design or Scope Changes	Relative level of implementation of sustainable design features	Cost and Schedule	Achieving specific LEED Ratings for buildings, etc.	
12	D2	Design or Scope Changes	Using unproven technology to implement sustainable design features	Cost and Schedule		
12,13, 14, 15	D3	Design or Scope Changes	Scope Creep	Cost and Schedule	Quantifying bridges of this type and how well they stay on schedule	
14	D4	Design or Scope Changes	Any Caltrans or Federal Highways requirements	Cost and		
All	E1	Economy/Market Conditions	Impact of adjacent planned transportation projects (i.e. POLA Southern California Intermodal Gateway Project, I-710 Widening Project)	Cost		
All Construction	E2	Economy/Market Conditions	steel prices)			
22	Ev1	Environmental	Potential environmental contamination in existing rail yard and North Harbor Area (asbestos, hydrocarbons, solvents, heavy metals, lead-based paint)	Cost and Schedule		
13	Ev2	Environmental	Any environmental impacts that would affect schedule	Schedule	If there are falcons on the bridge, any water wildlife that might be affected by operations	
All Construction	L1	Market or Labor	Risk of escalating labor costs	Cost		
All Construction	L2	Operations Work Windows	Any shipping changes required by the work, meaning if ships have to be delayed, or repositioned or if work on the bridge has to be delayed to allow particular ships to pass.	Schedule		
12	P1	Permitting & Stakeholder	Potential delays in environmental permitting schedule for programmatic EIR for Port Rail Program	Schedule		
12	P2	Permitting & Stakeholder	Impact to port clients in the areas where the bridge could affect their storage	Cost		Likely & impacts, maybe schedule
All Construction	Po1	Political	Risk of shut down due to environmental protests and political fall out (similar to the Foothill South Toll road in Orange County). primarily schedule risk that leads to cost risk.	Cost and Schedule		
All	Po2	Political	Risks of changes to environmental requirements due to pending or expected issues around the ports (note media discussions of higher cancer risk at and around the ports)	Cost and Schedule		
All Construction	Pr1	Procurement	Material procurement and management (owner procurements vs. contractor procurement)	Cost		
21-25	U1	Utilities	Any delays caused by utilities in the existing bridge or in the area of abutments, etc. that might need to be relocated	Schedule		

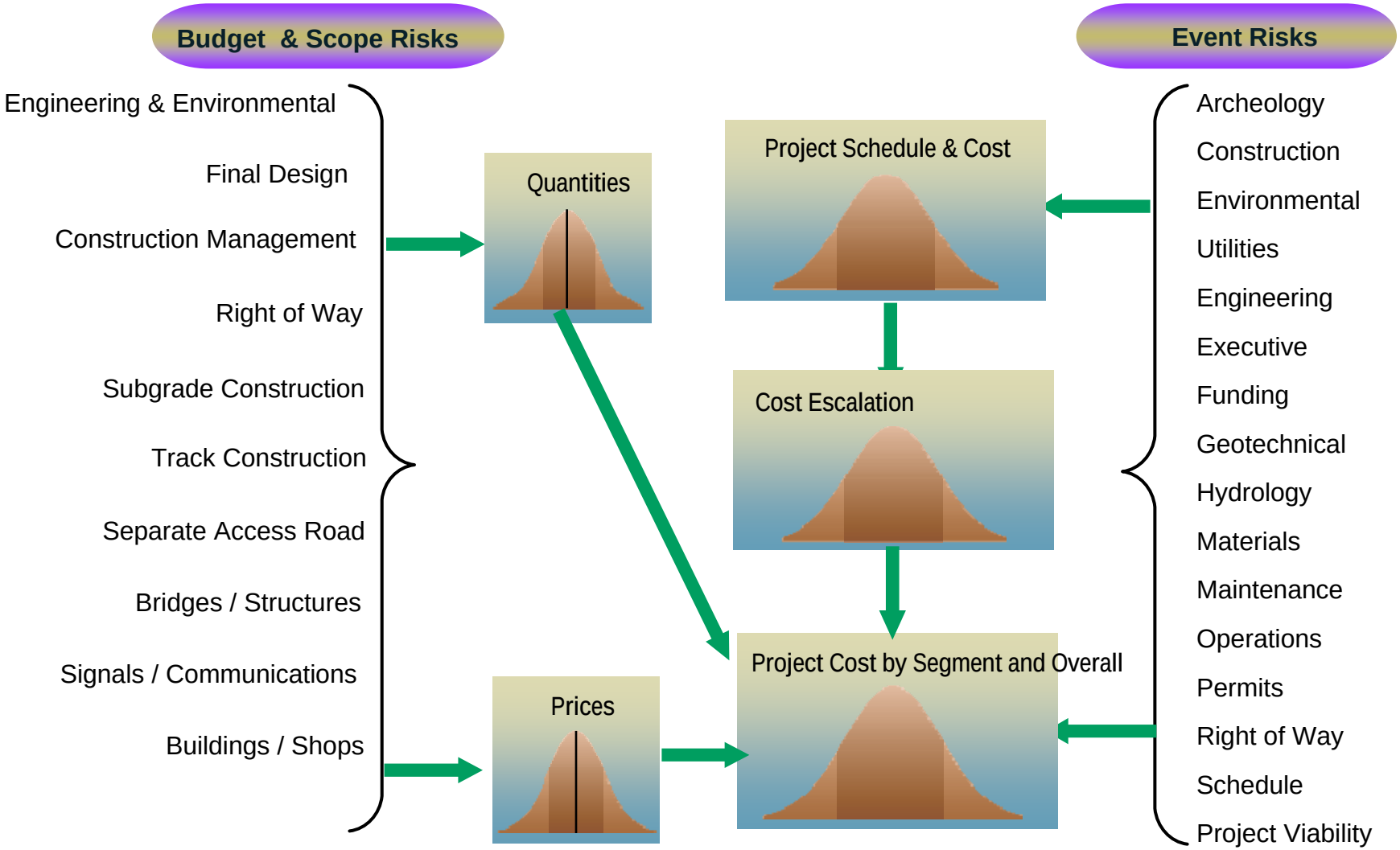
Step 1: Baseline Risk Assessment
Risk Register: Risk Quantification

Prob.	NON MITIGATED Cost Impact ($)				Schedule Impacts (months)			
	Distribution	Median	Low	High	Distribution	Median	Low	High
10%		$10,000,000	$8,000,000	$25,000,000	Trigen	5.0	2.0	10.0
15%	Trigen	$1,000,000	$250,000	$10,000,000	Trigen	4.0	2.0	6.0
80%	Trigen	$7,500,000	$250,000	$10,000,000	Trigen	2.0	1.0	3.0
50%	Trigen	$15,000,000	$10,000,000	$20,000,000	Trigen	4.0	2.0	6.0
15%	Trigen	$7,500,000	$250,000	$10,000,000	Trigen	2.0	1.0	3.0
0%	Trigen							
75%	Trigen	$7,500,000	$250,000	$10,000,000				
10%	Trigen	$1,000,000	$250,000	$10,000,000	Trigen	2.0	1.0	3.0
20%					Trigen	4.0	2.0	6.0
80%	Trigen	$8,000,000	$5,000,000	$12,000,000				
25%					Trigen	2.0	1.0	3.0
15%					Trigen	4.0	2.0	6.0
0%	Trigen	$7,500,000	$250,000	$10,000,000				
15%	Trigen	$1,000,000	$250,000	$10,000,000	Trigen	2.0	1.0	3.0
30%	Trigen	$5,000,000	$2,000,000	$20,000,000	Trigen	4.0	2.0	6.0
5%	Trigen	$500,000	$250,000	$750,000				
40%					Trigen	4.0	2.0	6.0

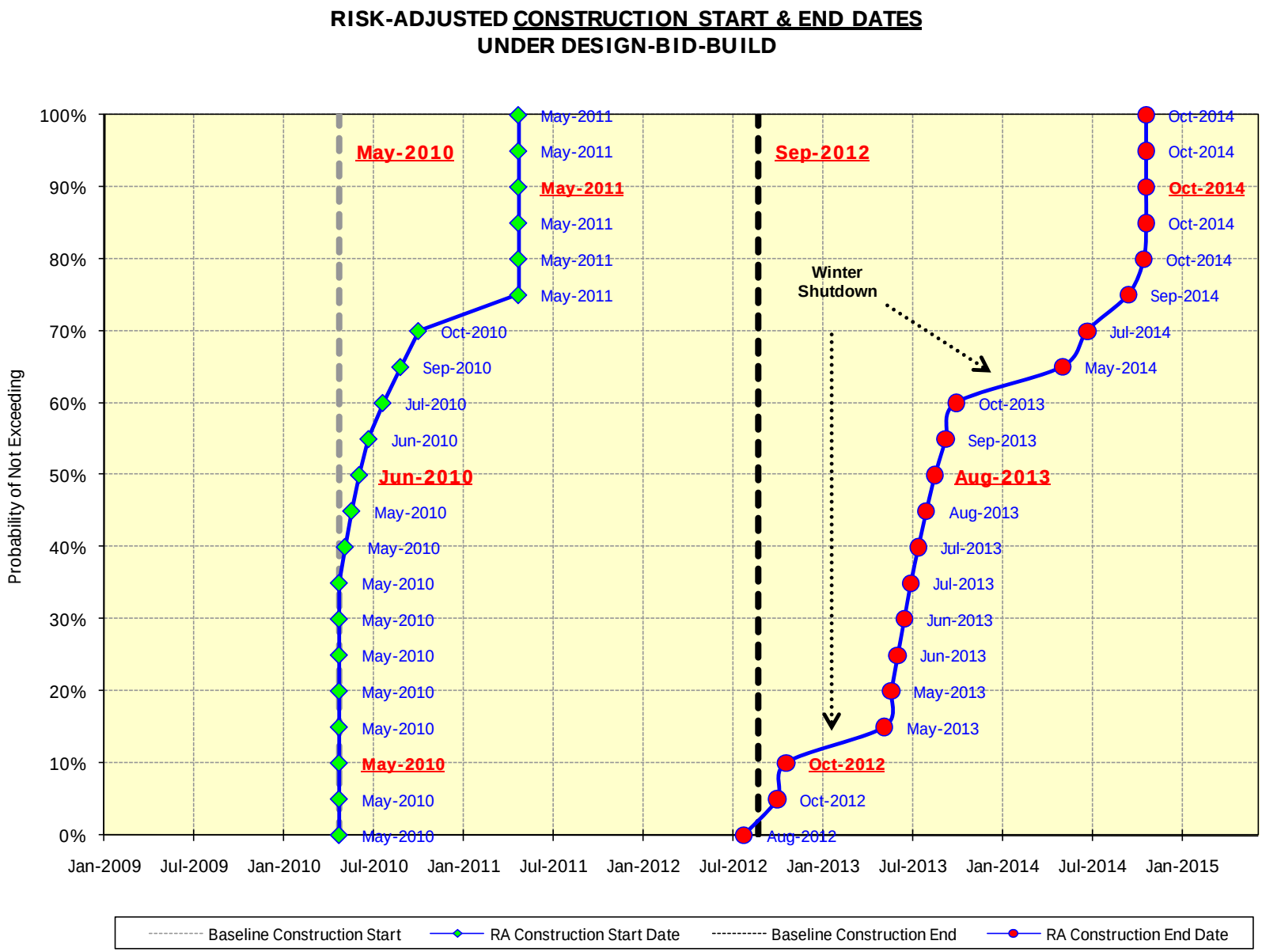
Step 1: Baseline Risk Assessment
Risk Register: Risk Mitigation

Response		Mitigated Prob.	Mitigated Cost Impacts			Mitigated Schedule Impacts		
Strategy	Response Actions Including Advantages and Disadvantages		v1	v2 (L)	v3 (H)	v1	v2 (L)	v3 (H)
Acceptance								
Mitigation	Adjust design to account for higher level of sustainable design features	10%	$500,000	$125,000	$5,000,000	2.00	1.00	3.00
Acceptance								
Acceptance								
Mitigation	Communicate with Caltran during planning phase	25%	$3,750,000	$125,000	$5,000,000	1.00	0.50	1.50
Acceptance								
Mitigation	Purchase materials early	15%	$3,750,000	$125,000	$5,000,000	0.00	0.00	0.00
Acceptance								
Acceptance								
Mitigation	Hire non-union labor	15%	$4,000,000	$2,500,000	$6,000,000	0.00	0.00	0.00
Acceptance								
Acceptance								
Mitigation	Research other area storge and inform current occupants of their options	5%	$3,750,000	$125,000	$5,000,000	0.00	0.00	0.00
Mitigation	Marketing	75%	$5,000,000	$125,000	$5,000,000	1.00	0.50	1.50
Mitigation	Marketing	5%	$2,500,000	$1,000,000	$10,000,000	2.00	1.00	3.00
Mitigation	Plan who is required to purchase materials	10%	$250,000	$125,000	$375,000	0.00	0.00	0.00
Acceptance								

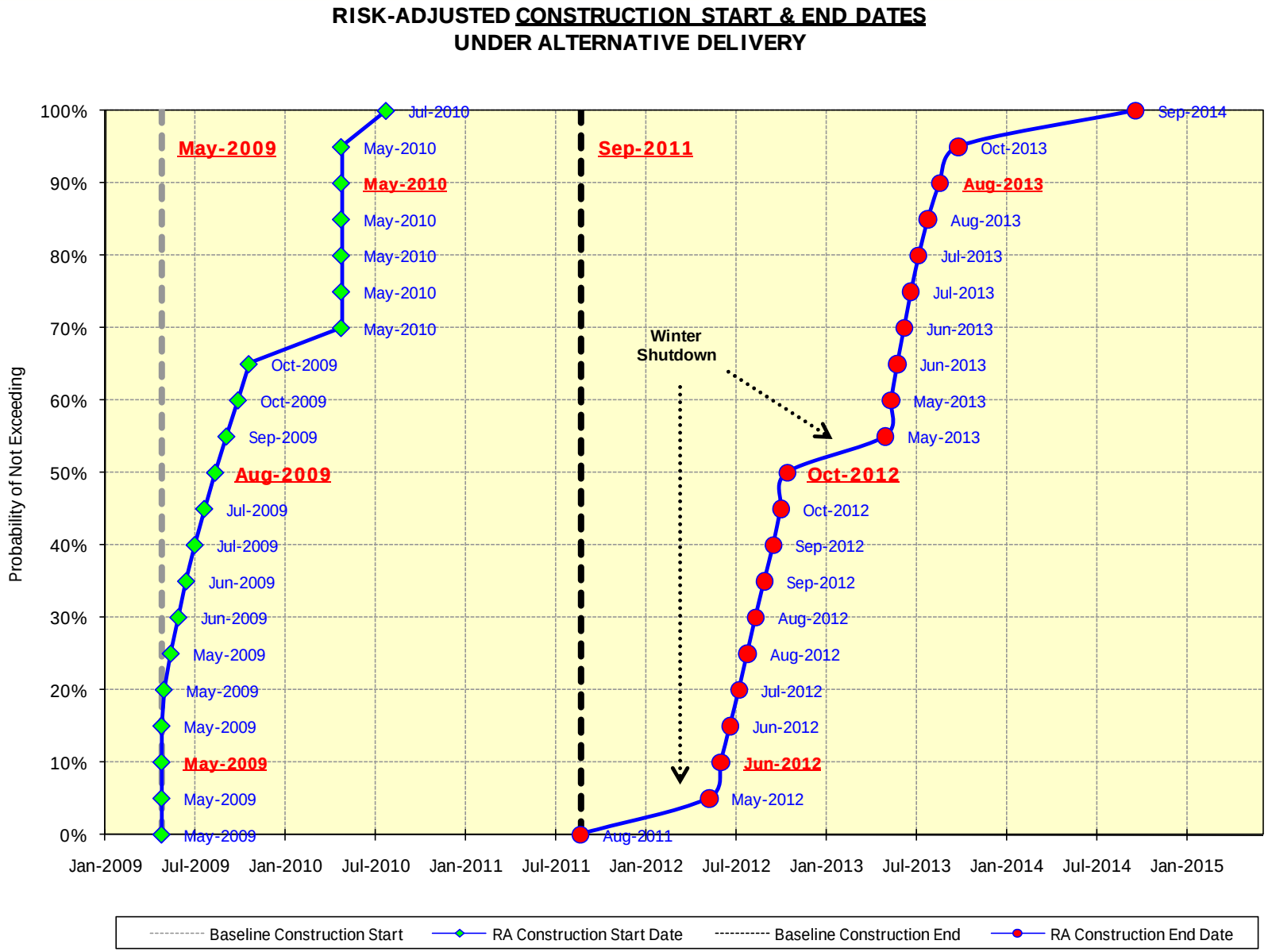
Step 1: Baseline Risk Assessment
Integrating Individual Risks



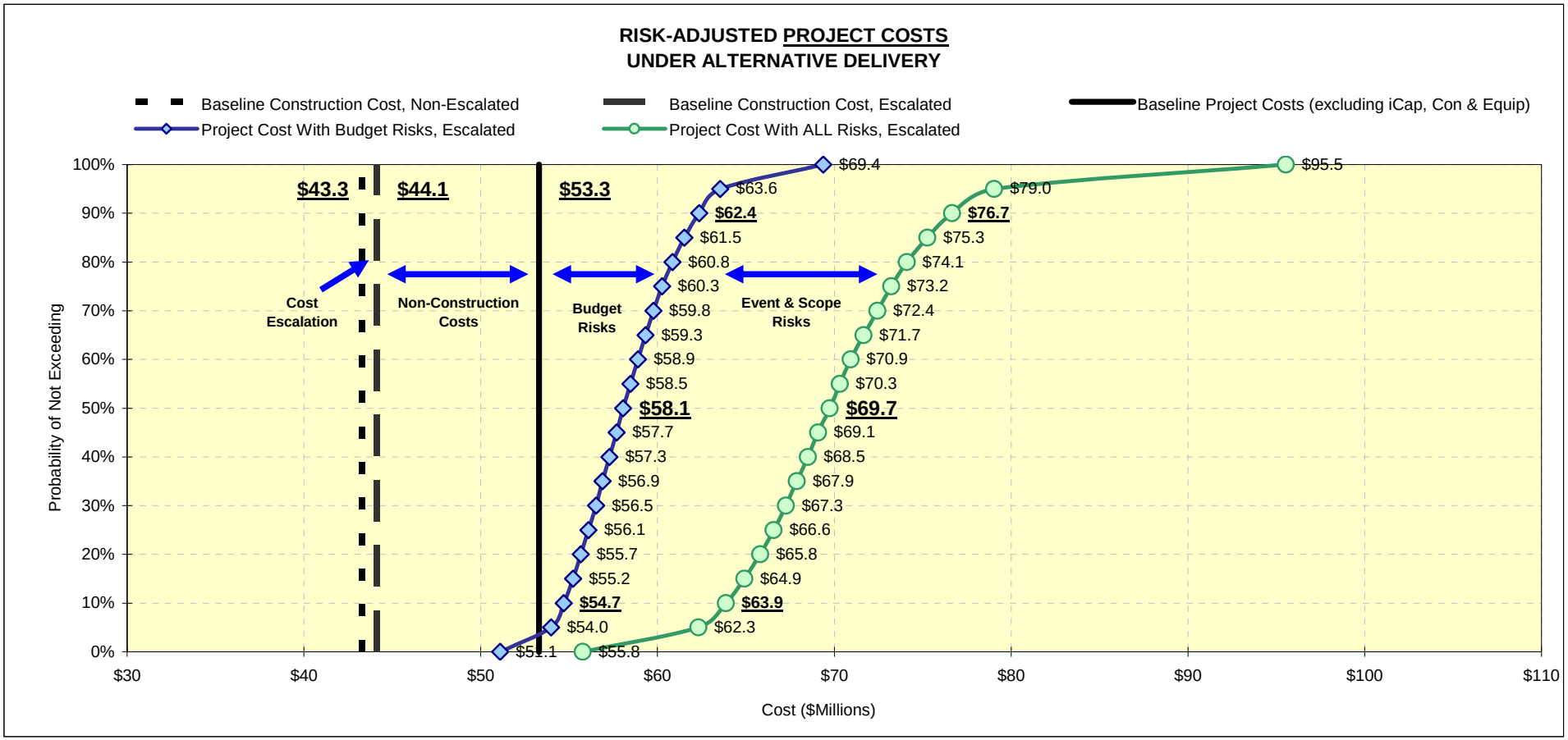
Step 1: Baseline Risk Assessment
Risk-Adjusted Schedule



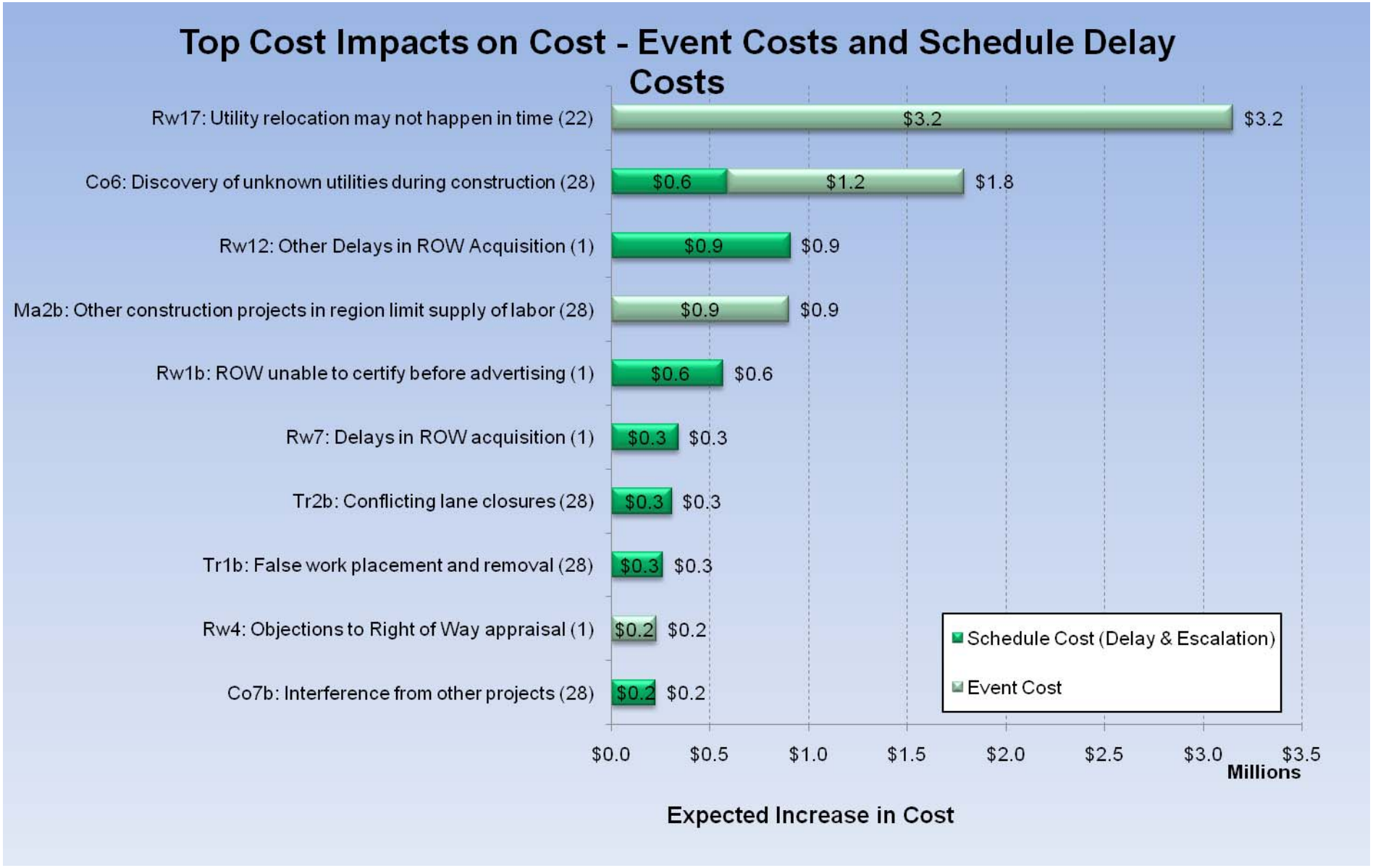
Step 1: Baseline Risk Assessment
Under Different Procurement Alternatives



Step 1: Baseline Risk Assessment
Risk-Adjusted Cost

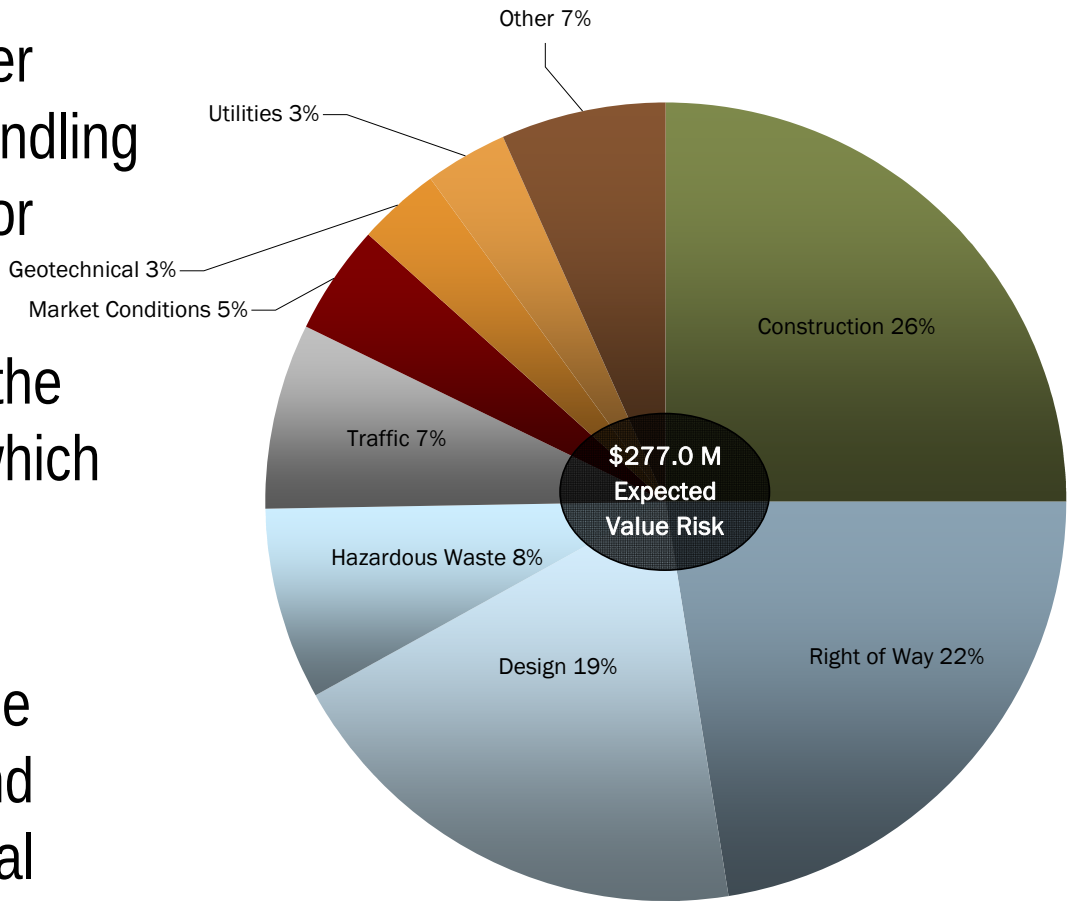


Step 1: Baseline Risk Assessment
Prioritization of Risks

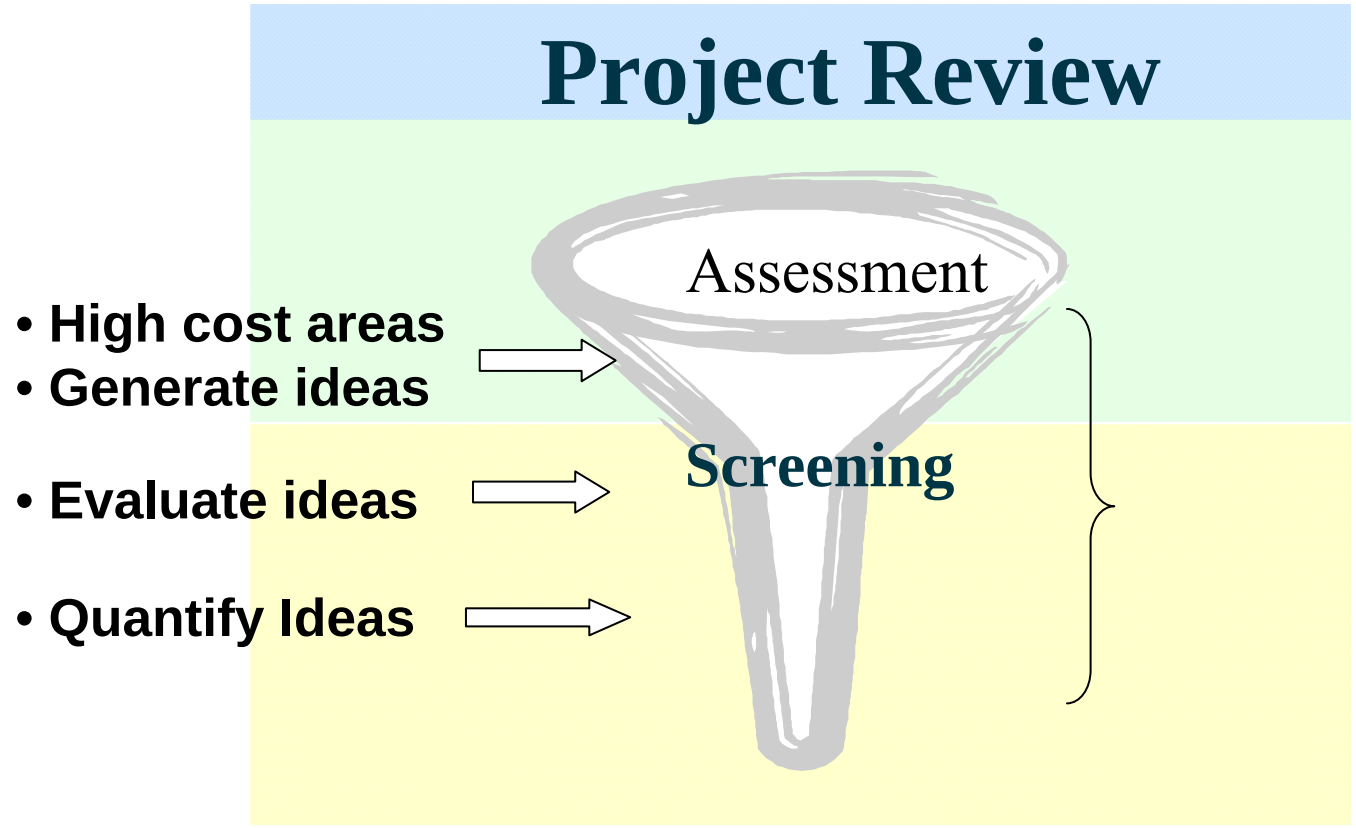


Step 2: VE & Risk Response
Focused Risk Responses

- 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



Step 2: VE & Risk Response
Value Engineering Assessment



Step 2: VE & Risk Response
Developing Risk Response Strategies

Risk ID: C3 - E
Risk Name: Defective work results in schedule delay and additional costs
Activity Impacted: 27
Type of Risk: Schedule
Expected Value Total Risk Impact ($M): $3.40
Panelist Comments from Initial Risk Workshop: Would require a change order, may extend the length of the contract.

Risk Response Strategy (select one): □ Avoid □ Transfer x Mitigate □ Accept

Notes on Strategy:

- Require schedule recovery whenever the Contractor's CPM begins to fall behind
- Use incentive/disincentive clause to encourage contract to be completed on time
- Consider A+B bidding for these projects
- Add additional inspection

Cost to Mitigate ($M): $1.0 to $2.0

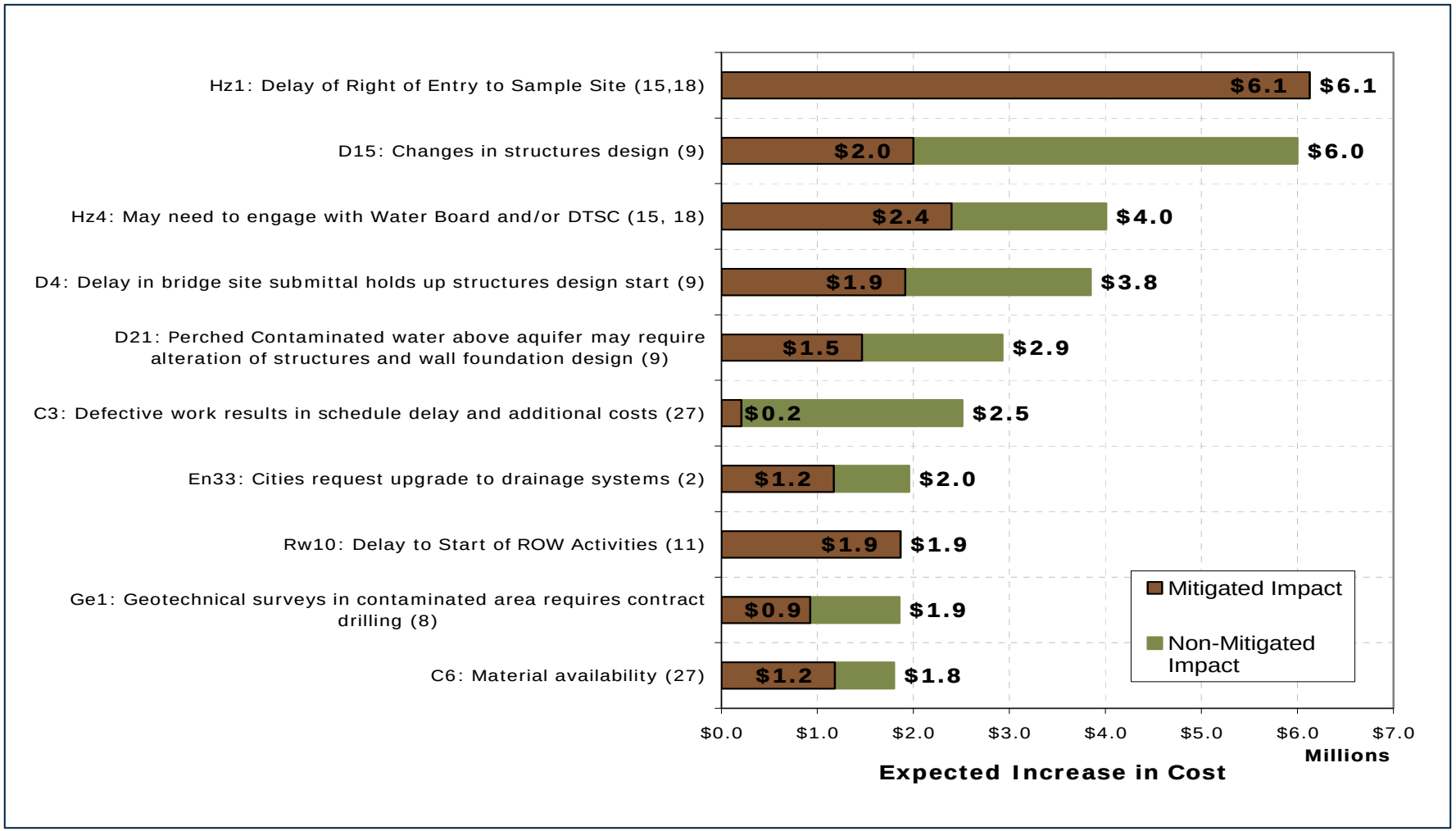
Risk Profile	Prob.	Impact		
		Low	Median	High
Cost Risk ($)	50%	n/a	n/a	n/a
Schedule Risk (Months)		2	3	18

Mitigated Risk Profile	Mitigated Prob.	Mitigated Impact		
		Low	Median	High
Cost Risk ($)	10%	n/a	n/a	n/a
Schedule Risk (Months)		1	4	6

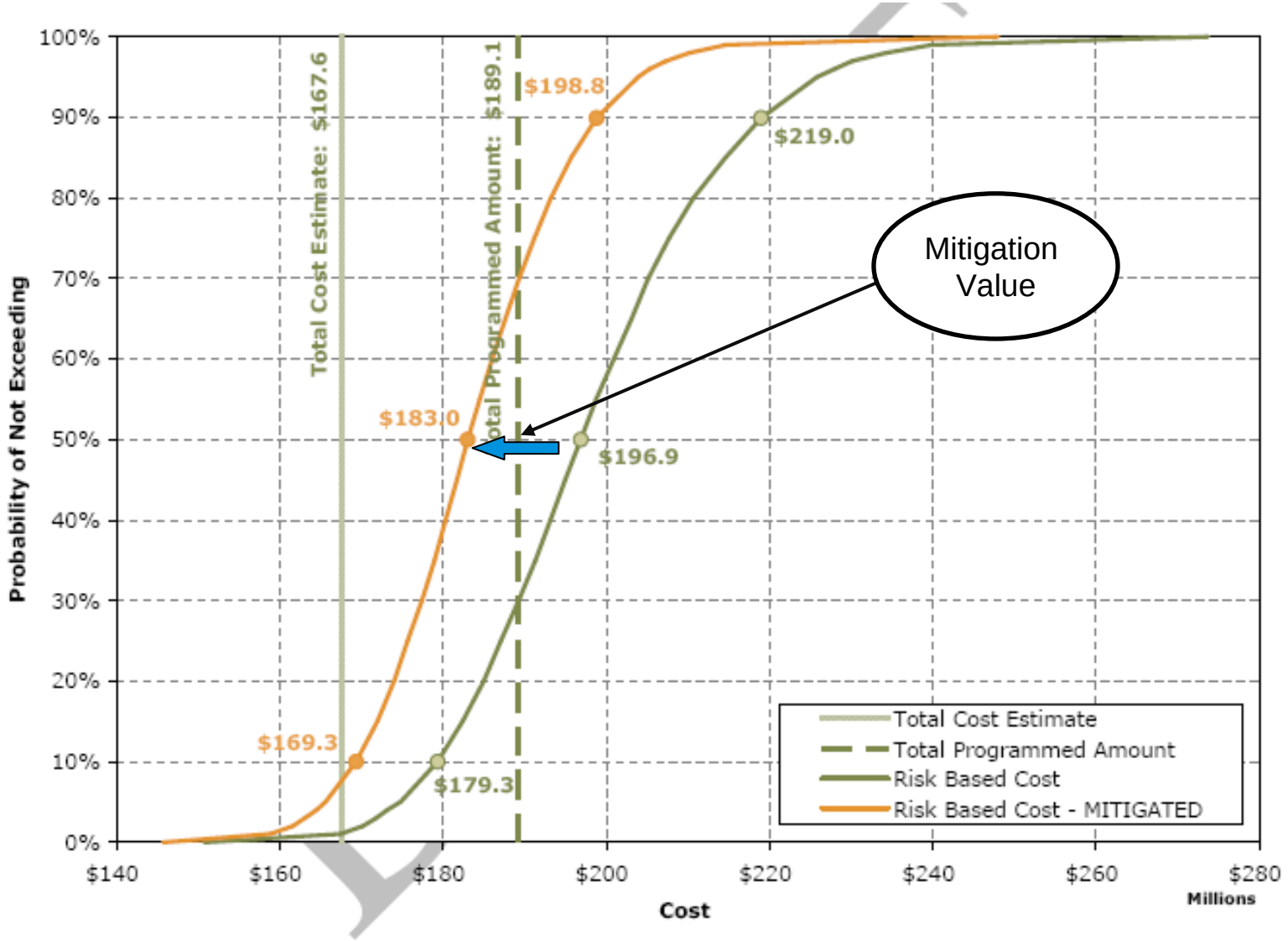
Step 3: Risk Analysis on Response Strategies Quantification of Mitigation Impact for Each Risk

Updated Risk Register → Assessment of Threats and Opportunities Related to VE and Response Strategies ← VE Recommendations Cost and Schedule Estimates

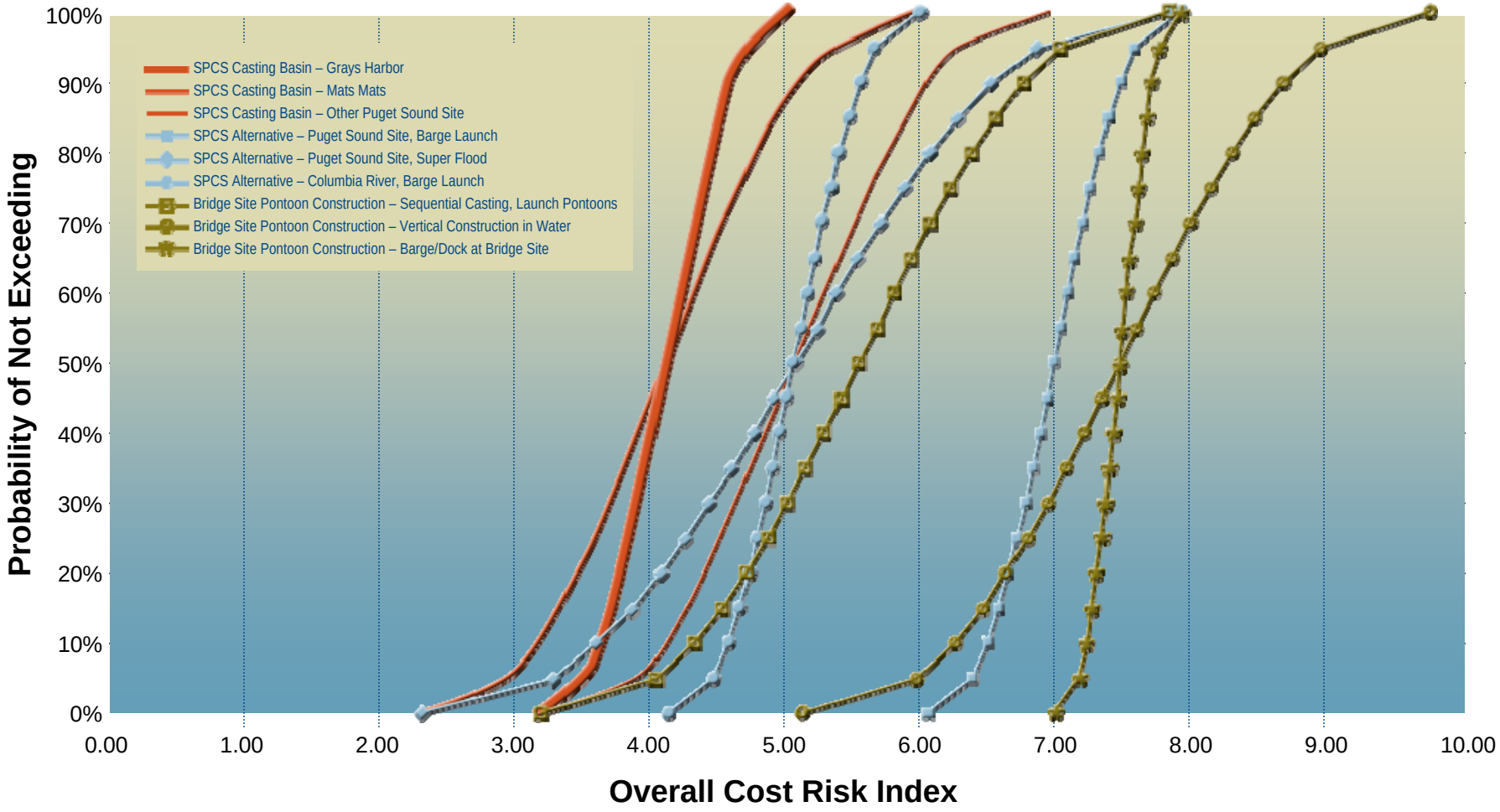
Step 3:
Risk Analysis on Response Strategies



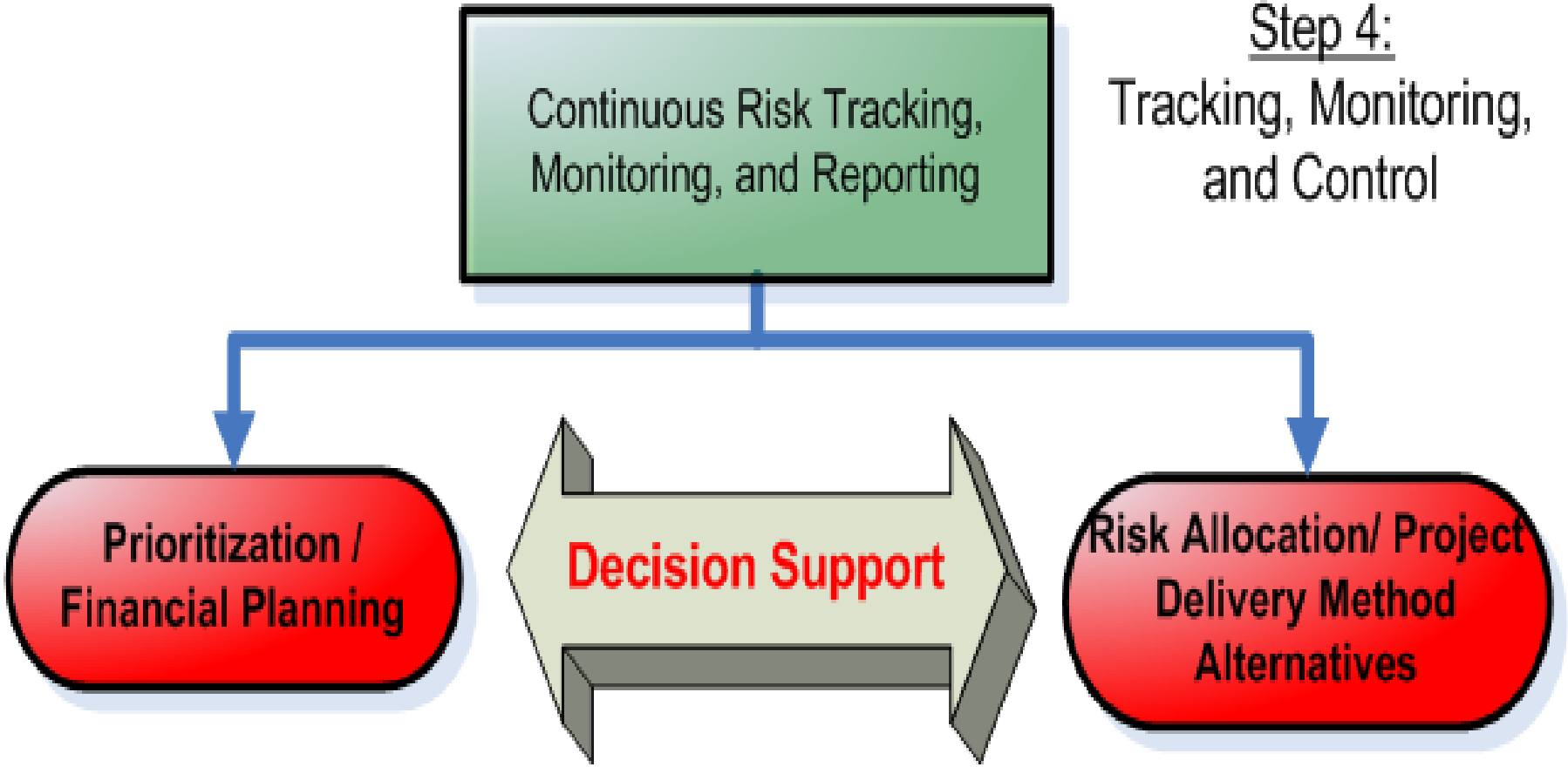
Step 3: Risk Analysis on Response Strategies
Quantifying Mitigation Strategies at the Project Level



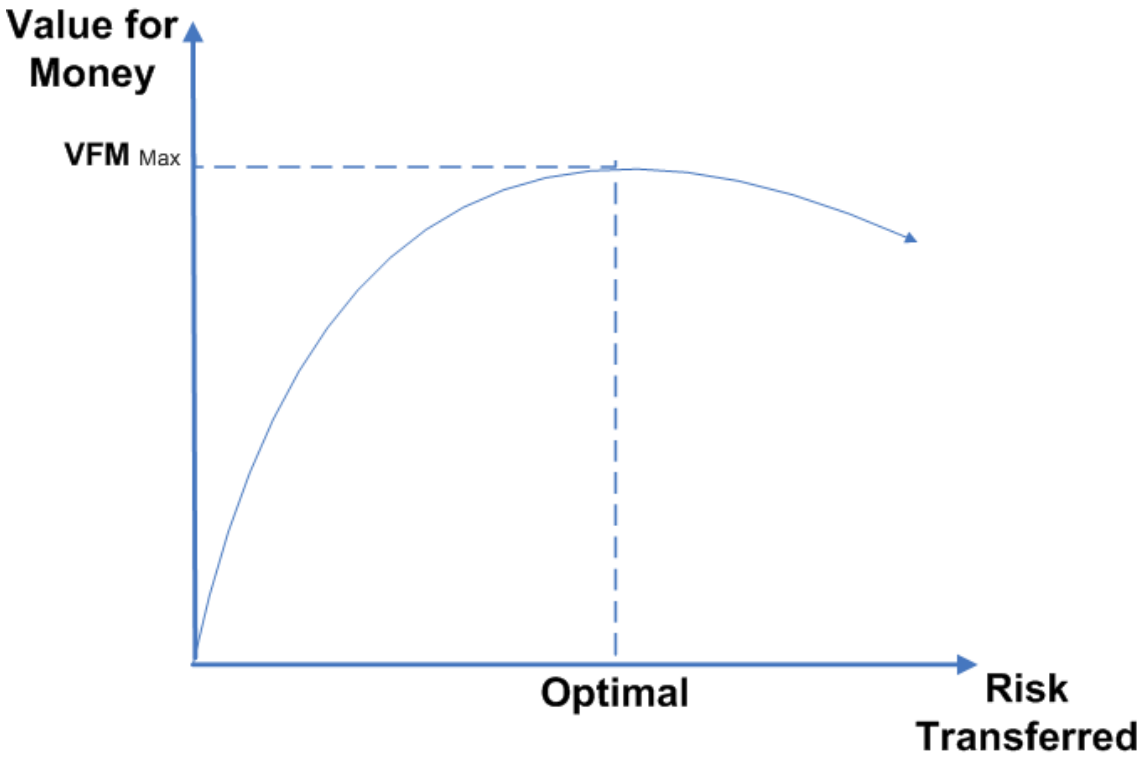
Step 3: Risk Analysis on Response Strategies
Assessment of Alternatives



Step 4: Tracking, Monitoring and Control
Tracking, Monitoring, and Control



Step 4: Tracking, Monitoring and Control
Informed Risk Allocation



Contractors do not take risks

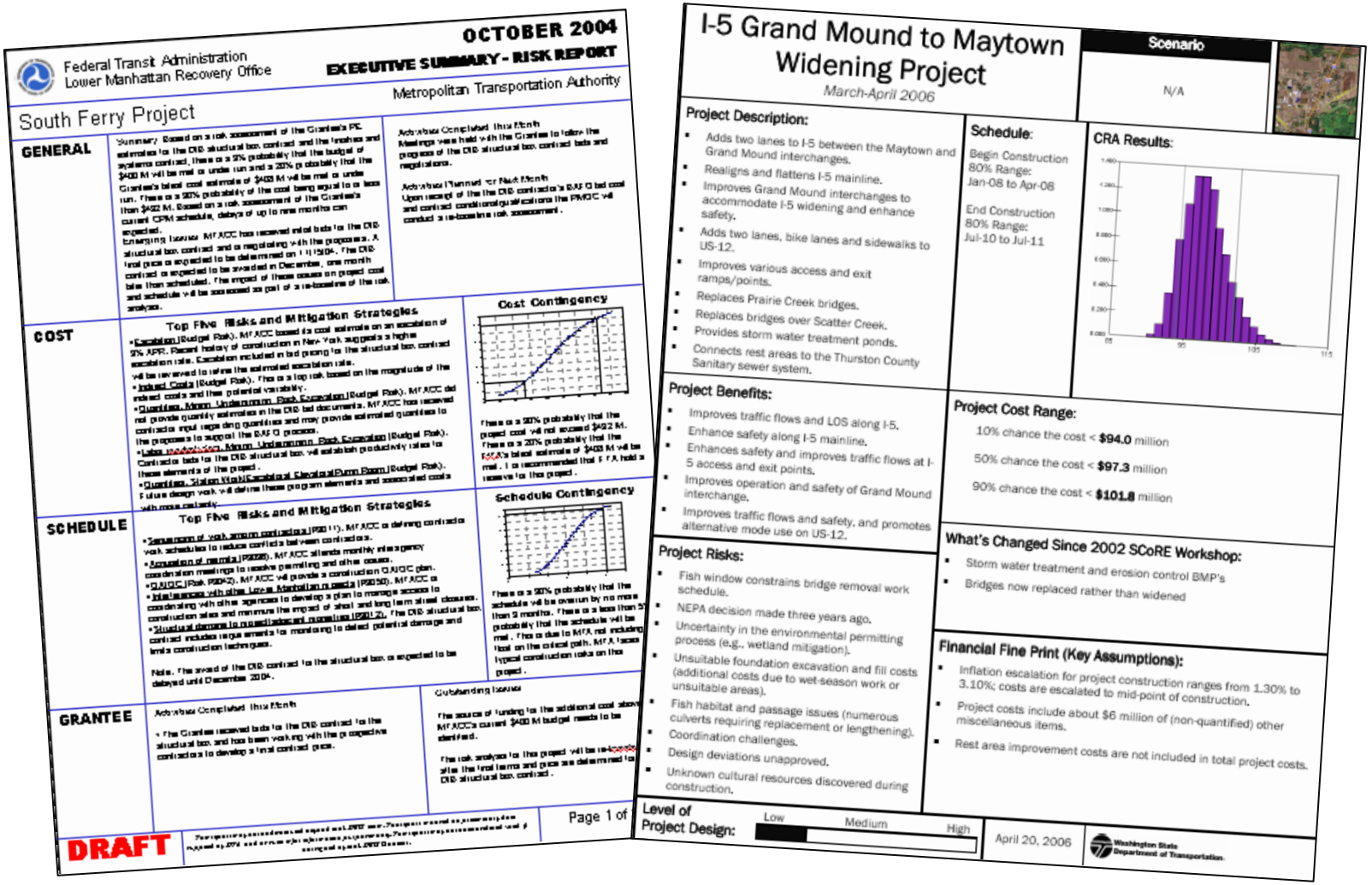
They Price It

P3: Looking for Win-Win

	Government Partners			Private		
	Public Expenditure/ Investment	Public Benefits	Public Net Benefits	Corporate Expenditure/ Investment	Corporate Benefits	Corporate Net Benefits
Private:	0		-	$88 M	$65 M	($23 M)
P3:	$51 M	$90 M	$39 M	$37 M	$65 M	$28 M

Basis for P3 Arrangement

Step 4: Tracking, Monitoring and Control
Adequate and Continuous Reporting



Federal Transit Administration
Lower Manhattan Recovery Office

OCTOBER 2004
EXECUTIVE SUMMARY - RISK REPORT
Metropolitan Transportation Authority

South Ferry Project

GENERAL

Summary: Based on a risk assessment of the Grantee's PE estimates for the DB structural box contract and the finishes and systems contract, there is a 5% probability that the budget of $400 M will be met or under run and a 20% probability that the Grantee's latest cost estimate of $403 M will be met or under run. There is a 80% probability of the cost being equal to or less than $402 M. Based on a risk assessment of the Grantee's current CPM schedule, delays of up to nine months can be expected.

Emerging Issues: MTACC has received initial bids for the DB structural box contract and is negotiating with the proposers. A final price is expected to be determined on 11/15/04. The DB contract is expected to be awarded in December, one month later than scheduled. The impact of these issues on project cost and schedule will be assessed as part of a re-baseline of the risk analysis.

Activities Completed This Month:
Meetings were held with the Grantee to follow the progress of the DB structural box contract bids and negotiations.

Activities Planned for Next Month:
Upon receipt of the the DB contractor's BAFO bid cost and contract conditional qualifications the PMOC will conduct a re-baseline risk assessment.

COST

Top Five Risks and Mitigation Strategies

- Excavation (Budget Risk). MTACC based its cost estimate on an escalation of 5% APR. Recent history of construction in New York suggests a higher escalation rate. Excavation included in bid pricing for the structural box contract will be reviewed to refine the estimated escalation rate.
- Indirect Costs (Budget Risk). This is a top risk based on the magnitude of the indirect costs and their potential variability.
- Quantities, Mined Underpinning, Rock Excavation (Budget Risk). MTACC did not provide quantity estimates in the DB bid documents. MTACC has received contractor input regarding quantities and may provide estimated quantities to the proposers to support the BAFO process.
- Labor productivities, Mined Underpinning, Rock Excavation (Budget Risk). Contractor bids for the DB structural box will establish productivity rates for these elements of the project.
- Quantities, Station Work (Exceptional Elevated Form Room) (Budget Risk). Future design work will define these program elements and associated costs with more certainty.

Cost Contingency

There is a 90% probability that the project cost will not exceed $422 M. There is a 20% probability that the MTACC's latest estimate of $403 M will be met. It is recommended that FTA hold a reserve for this project.

SCHEDULE

Top Five Risks and Mitigation Strategies

- Sequencing of work among contractors (P0011). MTACC is defining contractor work schedules to reduce conflicts between contractors.
- Acquisition of permits (P0020). MTACC attends monthly interagency coordination meetings to resolve permitting and other issues.
- CLOSC (Risk P0042). MTACC will provide a construction CLOSC plan.
- Interfaces with other Lower Manhattan projects (P0050). MTACC is coordinating with other agencies to develop a plan to manage access to construction sites and minimize the impact of short and long term street closures.
- Structural damage to surrounding buildings and properties (P0012). The DB structural box contract includes requirements for monitoring to detect potential damage and limit construction techniques.

Note: The award of the DB contract for the structural box is expected to be delayed until December 2004.

Schedule Contingency

There is a 90% probability that the schedule will be overrun by no more than 9 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 this project.

GRANTEE

Activities Completed This Month:
The Grantee received bids for the DB contract for the structural box and has been working with the prospective contractors to develop a final contract price.

Outstanding Issues:
The source of funding for the additional cost above MTACC's current $400 M budget needs to be identified.

The risk analysis for this project will be re-baselined after the final terms and price are determined for the DB structural box contract.

DRAFT

Page 1 of

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

HDR and Risk Assessment

- Conducted 500+ economic and financial studies in past 20 years
- Trusted by bond issuers and insurers; federal, provincial/state and local agencies
- Risk-based models for Transport Canada, FTA, FHWA, FRA, FAA, DOJ, and DHS that have been submitted to congressional committees, GAO and OMB
- Risk-based cost benefit analysis models for the Port Authority of NY / NJ, Metrolinx, Move Ontario 2020, City of London, City of Winnipeg, Vancouver to assess infrastructure investments

HDR and Cost Risk Assessment

- Conducted cost risk analysis for various infrastructure investment including *bridges*, *highways, rail alignments, ports, airports, tunnels, water treatment facilities, and convention centers*
- Led risk analysis studies for transportation agencies, such as *Caltrans, WSDOT, MNDOT, WISDOT, FDOT, UDOT, TXDOT, ADOT and the FTA* including Lower Manhattan Recovery Office in New York City
- Conducted program cost risk analysis for a $35 billion program by New York Dept. of Environmental Protection.
- Risk analysis for over $10 billion rebuild program in New Orleans on behalf of the US Army Corps of Engineers

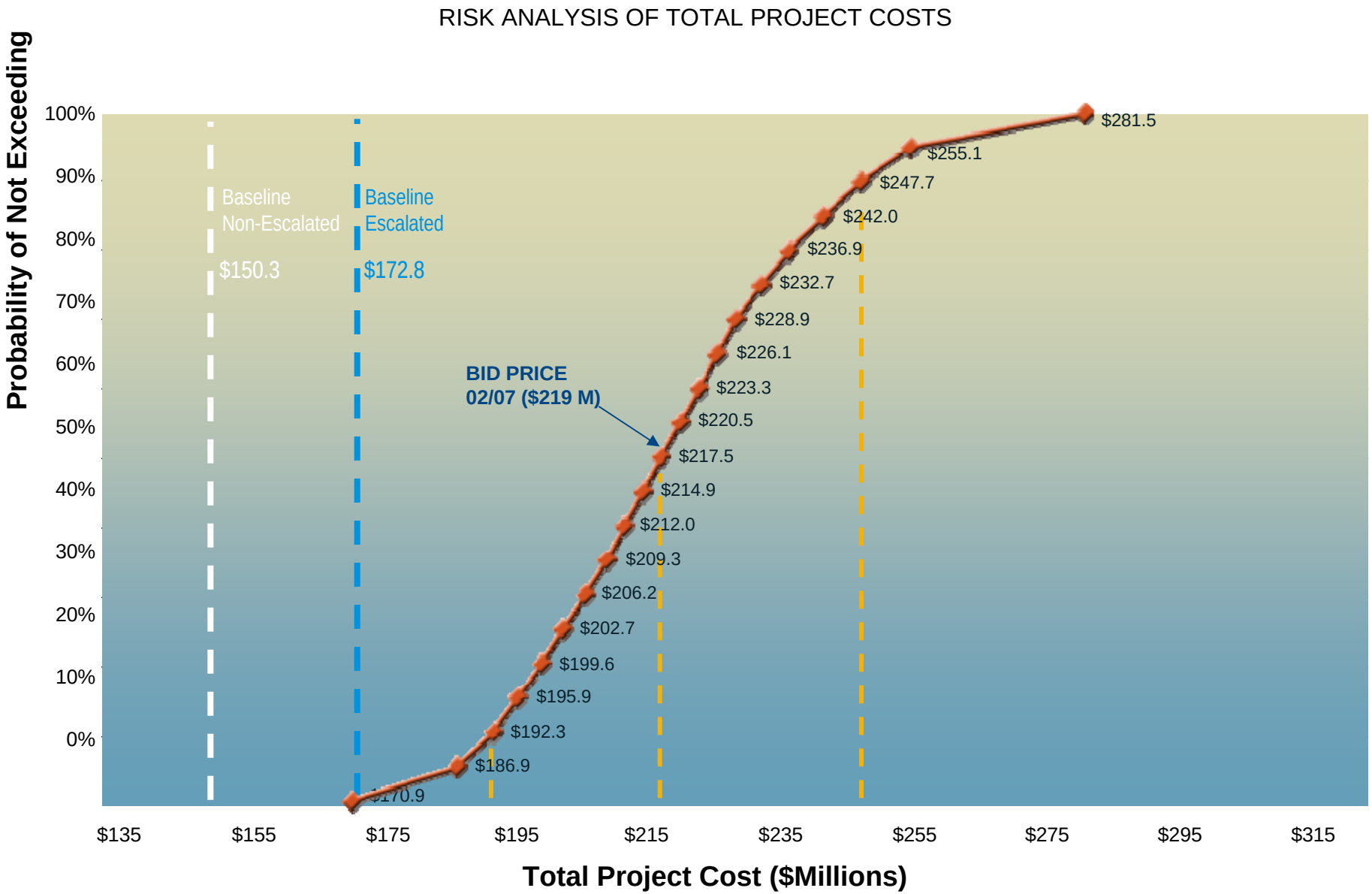
Questions?

“Probabilities direct the conduct of the wise person”

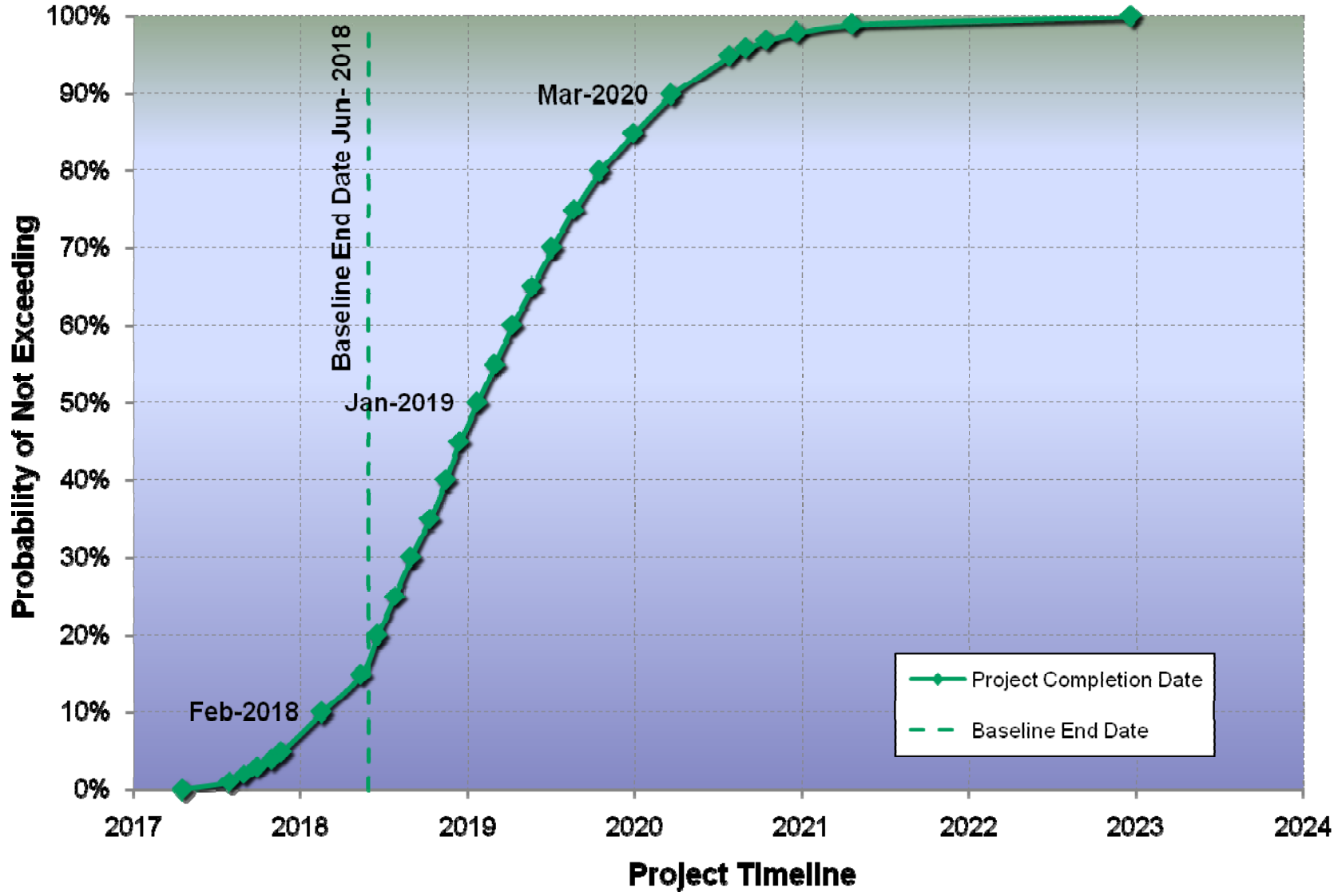
Cicero

Backup

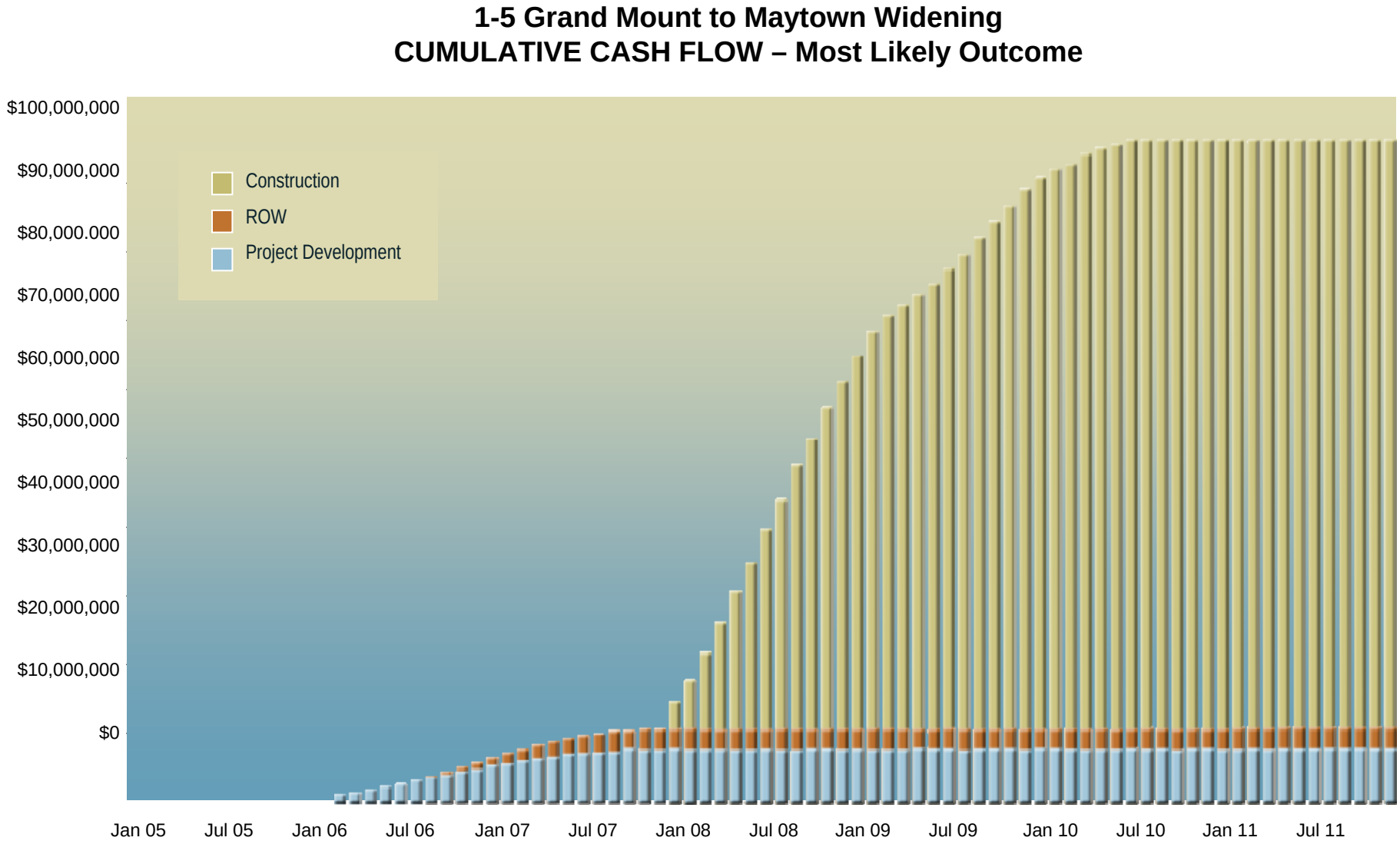
CRAVE™ Process: Step 1
Non-Mitigated Risk-Adjusted Cost Estimates



CRAVE™ Process: Step 1
Non-Mitigated Risk-Adjusted *Schedule Projection*



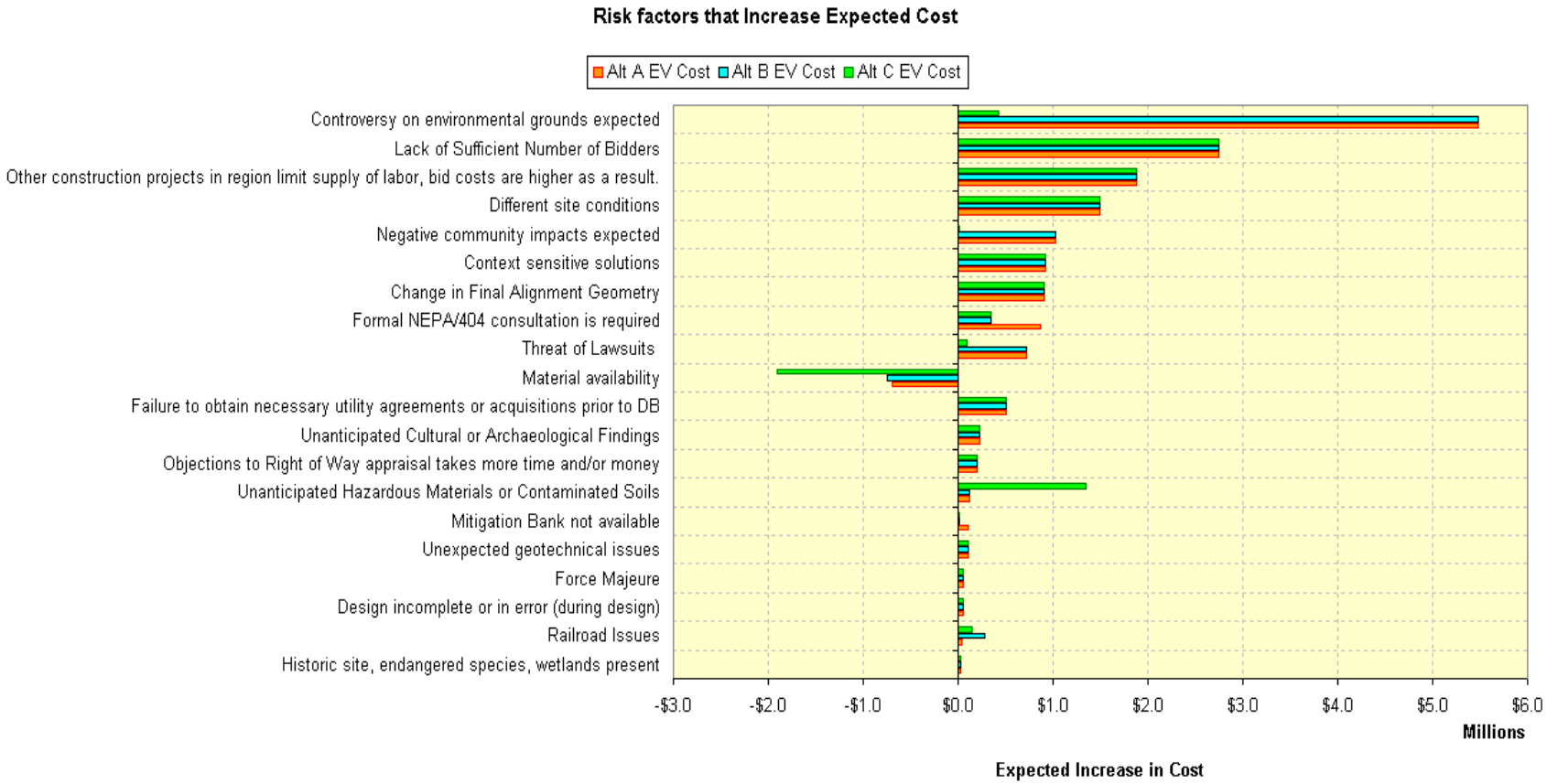
Cash Flow Analysis



Examples of Risk Mitigation

- Modified contract packages and terms
- Early purchase of critical or long-lead items
- Early purchase of Right-of-Way or lease of staging areas
- Additional geotechnical investigation to better define risk
- Enhanced public participation
- Negotiating community agreements upfront

Identification of Key Cost Ris



Note: This chart is based solely on the risk register: for each event risk, the expected cost impact is calculated as the product of the probability of occurrence times the cost estimate, both provided by the panelists.