SHRP2 R09

Managing Risk in Rapid Renewal Projects

TRAINING FOR RISK FACILITATORS

Phoenix, Arizona

October 27-28, 2016

Arizona Department of Transportation

U.S. Department of Transportation
Federal Highway Administration

SHRP2
STRATEGIC HIGHWAY RESEARCH PROGRAM

AASHTO
THE VOICE OF TRANSPORTATION

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

FHWA SHRP2 R09 Training for Risk Facilitators
Arizona Department of Transportation

Table of Contents

AGENDA

FHWA SHRP2 R09 Training for Risk Workshop Facilitators

Arizona Department of Transportation

October 27-28, 2016 Session

2302 W. Durango St.
Phoenix, AZ 85009

Instructors: Jerry DiMaggio P.E. and Paul Dalbey, P.E.

Day 1: October 27, 2016	
8:30am - 9:20am	Opening Remarks and Introduction
9:20am - 10:10am	Module 1 – Risk Management Process
10:10am – 10:25am	BREAK
10:25am -12:00pm	Module 2 – Introduction to R09 Risk Management Template
12:00pm – 1:00pm	LUNCH
1:00pm – 1:45pm	Module 3 – Project Scope, Strategy, and Conditions
1:45pm – 2:30pm	Module 4 – Structuring the Project for Risk Management
2:30pm - 2:45pm	BREAK
2:45pm – 3:45pm	Module 4 – Structuring the Project for Risk Management (cont.)
3:45pm – 4:20pm	Module 5 – Risk Identification
4:20pm – 4:30pm	Wrap-up Day 1 / Plan for Day 2 / Adjourn

Day 2: October 28, 2016	
8:30am - 8:40am	Day 1 Recap
8:40am – 9:15am	Module 5- Risk Identification (cont.)
9:15am – 10:00am	Module 6 – Risk Assessment
10:00am –10:15am	BREAK
10:15am – 11:25am	Module 6 – Risk Assessment (cont.)
11:25am – 12:00pm	Module 7 – Risk Management Planning
12:00pm – 1:00pm	LUNCH
1:00pm – 2:25pm	Module 7 – Risk Management Planning (cont.)
2:25pm – 2:40pm	BREAK
2:40pm – 3:45pm	Module 8 – Implementing the Risk Management Plan and the DOT Risk Management Program
3:45pm – 4:20pm	Module 9 – Probabilistic Risk Analysis
4:20pm– 4:30pm	Wrap-up Training / Training Evaluation / Training Adjourn

Training for Risk Workshop Facilitators

SHRP2 R09: Managing Risks on Rapid Renewal Projects

0-1

Introduction

- Opening Remarks
- **Instructor and Participant Introductions**
- SHRP2 Overview
- Course Goal and Learning Outcomes
- Training Agenda and Course Materials
- Training Logistics

0-2

Introductions

- In 25 words or less, share your:
  - Job responsibility
  - Experience with risk management
- Write down three specific learning outcomes (interests). These will be collected during the first break.

0-3

Introduction

- Opening Remarks
- Instructor and Participant Introductions
- **SHRP2 Overview**
- Course Goal and Learning Outcomes
- Training Agenda and Course Materials
- Training Logistics

0-4

What is SHRP2?

Tools to save lives, save money, save time.

- Products developed from objective, credible research
- Solutions that respond to challenges of the transportation community – safety, aging infrastructure, congestion
- Collaborative effort of AASHTO, FHWA, and TRB
- Tested products, refined in the field

SHRP2 Solutions offer new technologies and processes to enhance the efficiency of transportation agencies

0-5

Focus Areas

Safety: fostering safer driving through analysis of driver, roadway and vehicle factors in crashes, near crashes, and ordinary driving

Renewal: rapid maintenance and repair of the deteriorating infrastructure using already-available resources, innovations and technologies

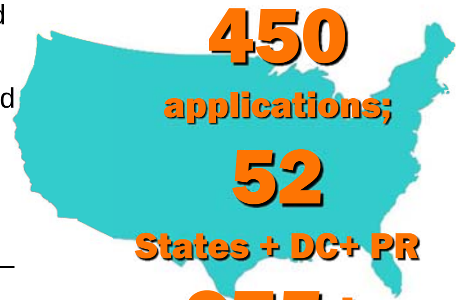
Capacity: planning and designing a highway system that offers minimum disruption and meets the environmental, and economic needs of the community

Reliability: reducing congestion and creating more predictable travel times through better operations

0-6

SHRP2 Implementation

- **SHRP2 Solutions** – more than 64 products bundled into 29 opportunities
- **Solution Development** – processes, software, testing procedures, and specifications
- **Field Testing** – refined in the field
- **Implementation** – 275+ transportation projects; adopt as standard practice
- **SHRP2 Education Connection** – connecting next-generation professionals with next-generation innovations



0-7

SHRP2 R09/R10 Project Management Tools

Guidelines to accelerate sound decision making and reduce risks during rapid construction projects.

- R09: *Managing Risk in Rapid Renewal Projects*
- R10: *Management Strategies for Complex Projects*

R09
R10

Related Product: *R07: Performance Specifications for Rapid Renewal Products*

R07

- Clarify desired performance for project selection, procurement, and specification development.
- Allows contractor ingenuity/innovation, reduction of costly oversight, and accelerate construction.

0-8

R09 - Managing Risk in Rapid Renewal Projects

R09

- ***Guide for the Process of Managing Risks on Rapid Renewal Projects***
  - Formal risk management process
  - Practical methods for identifying, assessing, mitigating, allocating, and monitoring risk
  - Tools include:
    - Risk/action checklist
    - Forms & MS Excel Template
    - Course to train DOT staff
- R09 Product Brief
- Link to Guidebook
  http://onlinepubs.trb.org/onlinepubs/shrp2/SHRP2prepubR09Guide.
- Link to TRB Tuesdays webinars
  http://www.trb.org/StrategicHighwayResearchProgram2SHRP2/Blurbs/169261.aspx


SHRP2
FINAL
GUIDE FOR THE PROCESS OF MANAGING RISK ON RAPID RENEWAL PROJECTS
FEBRUARY 2011
Golder Associates

0-9

Value of R09 Risk Management

- Risk Identification, Risk Assessment, Risk Analysis
- Identification of Mitigations
- Mitigation Evaluation: cost effectiveness comparing cost and/or time to implement mitigation(s) vs. cost and/or schedule savings
- Comparison of cost, duration and disruption between:
  - Base vs. Unmitigated vs. Mitigated Scenarios
- Establishment of contingencies based on specific project risks:
  - Contingencies based on specific project risks rather than arbitrary percentages to total cost
  - Free up unnecessary contingencies for other program needs
- Powerful tool to document/communicate results to management and stakeholders and obtain necessary resources

0-10

R09 Current Users

SHRP2 Implementation Assistance Round	Participation Level	DOT
Round 1 – Feb. 2013	**Proof of Concept** - One workshop	Florida Georgia
Round 2 – Oct. 2013	**Lead Adopter** - One workshop, - One training, - 8 hrs. of Tech. Assist. (TA) - One Peer Exchange among all DOTs - Up to $100,000	Florida Minnesota Oregon Pennsylvania
Round 4- Aug. 2014	**User Incentive** - One workshop, or one training or 8 hrs. of TA - Up to $30,000	Alaska Alabama Arizona FHWA Fed. Lands Florida Pennsylvania Puerto Rico Wisconsin

0-11

Implementation Strategies

- Demonstration workshops
- Training
- Technical assistance
- Peer exchange
- Communications and outreach
  (factsheets, videos, events/conferences, committee presentations)
- Implementation Goals:
  - Encourage DOTs to adopt R09/R10 as part of their routine project management practices
  - Incorporate R09/R10 processes/lessons learned into FHWA's Project Management Guidance and procedures

0-12

SHRP2 R09/R10 Contact Information

Carlos F. Figueroa, P.E.
SHRP2 R09&R10 Program Manager
FHWA Office of Infrastructure
202-366-5266
carlos.figueroa@dot.gov

Keith M. Platte, P.E.
Engineering Program Manager
AASHTO
202-624-3697
kplatte@aashto.org

SHRP2 Implementation Assistance Websites
http://www.fhwa.dot.gov/goshrp2
http://shrp2.transportation.org/Pages/Default.aspx

0-13

Introduction

- Opening Remarks
- Instructor and Participant Introductions
- SHRP2 Overview
- **Course Goal and Learning Outcomes**
- Training Agenda and Course Materials
- Training Logistics

0-14

Course Goal

- Develop and enhance DOT capabilities to conduct and facilitate risk/opportunity management assessments

0-15

Course Learning Outcomes

- Identify project conditions and performance requirements where simple and complex risk/opportunity management (RM) methods can be applied
- Identify the steps of the RM process
- Conduct RM assessments for simple projects
- Formulate a RM Plan on a typical transportation project (QDOT Project)

0-16

Course Learning Outcomes (cont.)

- Document, interpret, and apply the results obtained with the RM process
- Communicate the results of RM process
- Apply the R09 Risk Template and implement results (e.g. cost, schedule, disruption, and longevity)

0-17

Introduction

- Opening Remarks
- Instructor and Participant Introductions
- SHRP2 Overview
- Course Goal and Learning Outcomes
- **Training Agenda and Course Materials**
- Training Logistics

0-18

Training Agenda

- Two (2) full days
- Lectures, exercises, and discussions
  - Modules
    - Learning outcomes
    - Concepts and definitions
    - Methods: process and guidance
    - QDOT case study exercise (hypothetical project) and discussion
    - Summary
  - Course reference and working materials
    - R09 Guidebook (*"Guide"*)
    - R09 MS Excel Risk Template (*"Template"*) and User's Manual
    - Training Book

0-19

Training Agenda

Day 1 – Instructor-led presentations with exercises, examples, discussion

- Opening Remarks and Introduction
- Module 1 – Risk Management Process
  - BREAK
- Module 2 – Introduction to R09 Risk Management Template
  - LUNCH
- Module 3 – Project Scope, Strategy, and Conditions
- Module 4 – Structuring the Project for Risk Management
  - BREAK
- Module 4 – Structuring the Project for Risk Management (cont.)
- Module 5 – Risk Identification
- Summary Day 1/Plan for Day 2/Adjourn

0-20

Training Agenda

Day 2 – Instructor-led presentations with exercises, examples, discussion

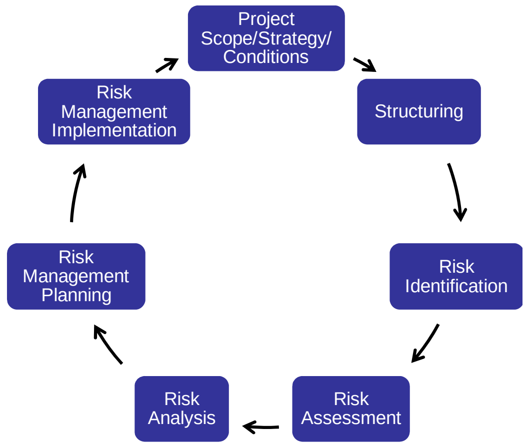
- Day 1 Recap and Module 5- Risk Identification (cont.)
- Module 6 – Risk Assessment
  - BREAK
- Module 6 – Risk Assessment (cont.)
- Module 7 – Risk Management Planning
  - LUNCH
- Module 7 - Risk Management Planning (cont.)
  - BREAK
- Module 8 – Implementing the *Risk Management Plan* and the *DOT Risk Management Program*
- Module 9 – Probabilistic Risk Analysis
- Training Evaluation/Training Adjourn

0-21

Course Modules & Guidebook Chapters

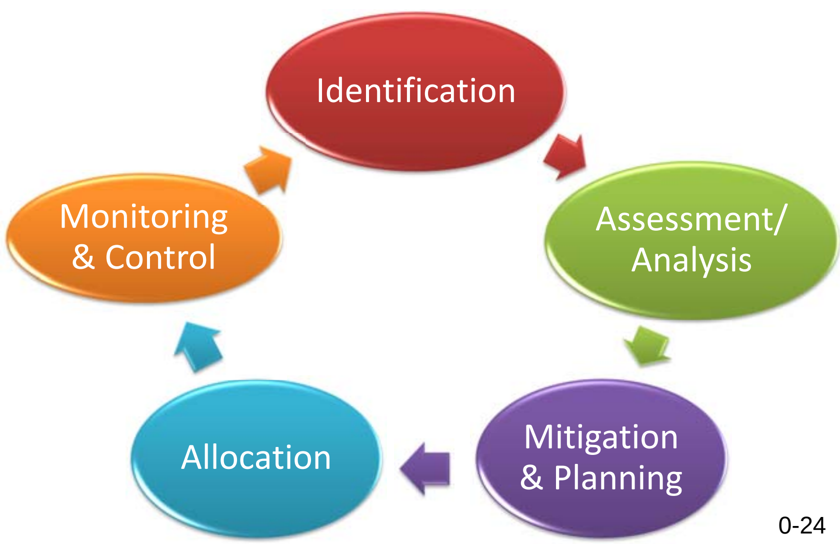
Course Module #	Guidebook (Guide) Chapter #	Template Step #
Mod. 0- Introduction (Guide Chap. 1)	Chap. 1- Introduction	1- Project Structuring
Mod. 1- Risk Management Background and Process (Guide Chap. 2)	Chap. 2- Risk Management Process	2- Risk Identification
Mod. 2- Introduction to R09 Risk Management Template (Guide Appendix E)	Chap. 3- Context for Rapid Renewal	3- Rating Scale
Mod. 3- Project Scope, Strategy and Conditions (Guide Chap. 4)	Chap. 4- Structuring a Project for Risk Management	4- Unmitigated Risk Assessment
Mod. 4- Structuring the Project for Risk Management (Guide Chap. 4)	Chap. 5- Risk Identification	5- Unmitigated Risk Register
Mod. 5- Risk Identification (Guide Chap. 5)	Chap. 6- Risk Assessment	6- Unmitigated Project Performance
Mod. 6- Risk Assessment (Guide Chap. 6)	Chap. 7- Risk Analysis (Probabilistic)	7- Unmitigated Risk Ranking Plots
Mod. 7- Risk Management Planning (Guide Chap. 8)	Chap. 8- Risk Management Planning	8- Risk Mitigation Strategies
Mod. 8- Implementing the Risk Management Plan and the DOT Risk Management Program (Guide Chap. 9, 10, 11)	Chap. 9- Implementing the Risk Management Plan	9- Mitigated Strategies Register
Mod. 9- Probabilistic Risk Analysis (Guide Chap. 7)	Chap. 10 - Implementing this Guide	10- Mitigated Risk Register
	Chap. 11- Summary and Conclusions	11- Mitigated Project Performance 12- Mitigated Risk Ranking

R09 Risk Management Introduction



0-23

FHWA Cost Estimate Review RM Process



0-24

Introduction

- Opening Remarks
- Instructor and Participant Introductions
- SHPR2 Overview
- Course Goal and Learning Outcomes
- Training Agenda and Course Materials
- **Training Logistics**

0-25

Questions?

goSHRP2@dot.gov

SHRP2 SOLUTIONS

Save lives. Save money. Save time.

0-26

Appendix A. Glossary

$B – billion dollars
$k – thousand dollars
$M – million dollars
DOT – department of transportation
Iff – if and only if
NPV – net present value
OH - overhead
RMP – Risk Management Plan
SME – subject matter expert
VE – value engineering
YOE – year-of-expenditure

Base (in risk context) – as used herein, value exclusive of risk and opportunity (i.e., per specific set of assumptions)
Bias (in risk context) – error in value (e.g., due to conservatism)
Conditional value – value if specific condition is true
Contingency – value in addition to base intended to cover risks and other uncertainties (e.g., for project cost and for project schedule)
Contingency management – process of establishing appropriate contingency allowances (e.g., to achieve specific level of confidence that budget and milestones will not be exceeded) and controlling its expenditure
Correlation (or correlated) – relationship between uncertain variables (e.g., tendency for one variable to be on the higher end of its range if another variable is on the high end of its range)
Critical path – the set of project activities that have zero float (i.e., a delay in an activity on critical path will delay project completion)
Critical path analysis – process of analyzing a project schedule to determine each activity's float and to identify the critical path
Deterministic analysis – process of calculating a single value for each output, based on single values of each input
Disruption – as used herein, a measure of project performance expressed in terms of the amount of hours lost by the public, which when combined with an average cost per hour, produces user cost
Escalation – process by which the costs of things change with time (including inflation)
Escalation rate – rate at which the cost of something changes with time, typically expressed in terms of percent cost increase per year (which might vary from year to year and for different items)
Expected value – mean value
Facilitator (in risk context) – specialist who guides the risk management process, e.g., working with appropriate project staff and SMEs to structure the project, identify and assess project risks, and develop risk management plans, and conducting the various analyses
Float (in schedule context) – amount of time an activity can be extended before it becomes critical path
Ignorance (in risk context) – lack of perfect information about the value of a particular factor, which leads to uncertainty
Impacts (in risk context) – as used herein, changes in base performance values (e.g., in project cost) associated with occurrence of a particular risk; often described as an impact "scenario"
Independent (in risk context) – no relationship between uncertain variables (i.e., not correlated)
Longevity – as used herein, a measure of project performance considering cost and disruption associated with operations and replacement, in combination with the time to replacement
Mean value – measure of the middle of the range of an uncertain variable; probability-weighted average value
Mitigated (or mitigation, in risk context) – after additional proactive risk reduction is attempted
Monte Carlo simulation – numerical method of approximately calculating probability distributions of outputs by sampling numerous sets of input values from their probability distributions, calculating the output values for each set of input values, and statistically analyzing the sets of output values

Opportunity (in risk context) – potential event that, if it occurs, would impact project performance, often expressed in terms of an impact “scenario” (a particular set of project performance impacts, such as acceleration to a particular project activity) and its probability of occurring; typically refers to potential events with desirable impacts

Percentile (in probability context) – value associated with a particular cumulative probability (e.g., the 90th percentile has a 90% chance of not being exceeded)

Probability – chance of occurrence, with possible values ranging from 0% (will not occur) to 100% (will occur)

Probability distribution – expression of relative likelihood of each possible value of an uncertain variable

Recovery (in risk context) – as used herein, actions to reduce project cost and/or schedule (e.g., scope reductions), typically in reaction to exceeding available contingency

Residual risk – remaining risk, typically after mitigation

Risk – potential event that, if it occurs, would impact (relative to base) project performance, often expressed in terms of an impact “scenario” (a particular set of project performance impacts, such as delay to a particular project activity) and its probability of occurring; typically refers to potential problems with undesirable impacts (“threats”), although can include opportunities as negative risks

Risk analysis – as used herein, process of calculating project performance including risks, and often the sensitivity of that performance to the various risks (i.e., to prioritize the risks for further assessment or for risk reduction), based on previous structuring and risk identification and assessment. As used elsewhere, sometimes refers broadly to identification and assessment, as well as analysis, of risks, interchangeably with risk assessment

Risk assessment – as used herein, process of assessing the severity of identified risks, typically by assessing the factors describing each identified risk (i.e., impacts and likelihood of occurrence), based on previous structuring and risk identification. As used elsewhere, sometimes refers broadly to identification and analysis, as well as assessment, of risks, interchangeably with risk analysis

Risk identification – as used herein, process of identifying project risks (e.g., through brainstorming, checklists, etc.), based on previous structuring, typically with the objective of developing a comprehensive and non-overlapping set of risks, as documented in a *risk register*

Risk management implementation – as used herein, process of actually carrying out the *Risk Management Plan*, including monitoring and updating. As used elsewhere, sometimes refers to risk monitor, evaluate and adjust or risk monitoring and review.

Risk management planning – as used herein, process of developing plans to control risks (and thereby project performance) through proactive risk reduction, contingency management and/or recovery, as documented in a *risk management plan*, based on previous structuring and risk identification, assessment and analysis. As used elsewhere, sometimes refers broadly to identification, assessment, and analysis, as well as risk response or risk treatment or control of risks

Risk Management Plan – documentation of the plans for conducting risk management, including organization to implement those plans; should be kept up-to-date

Risk management process – as used herein, broad iterative process of structuring, identifying/assessing/analyzing risks, and developing/implementing plans for controlling those risks, to optimize project performance

Risk reduction – process of proactively taking actions intended to reduce the impacts and/or probability of specific risks (or increase the impacts and/or probability of specific opportunities)

Risk Register – documentation of project risks, ideally comprised of a comprehensive and non-overlapping set of risks (typically categorized), including adequate descriptions of their impacts and likelihood; should be kept up-to-date

Severity (or risk severity) – as used herein, a measure of a risk’s impact on project performance, e.g., by combining mean values of changes in cost, schedule, and disruption through construction, and post-construction longevity, due to that risk

Standard deviation – measure of the range of an uncertain variable; square root of the variance

Structuring (in risk context) – as used herein, process of defining base project performance, e.g., by reviewing/abstracting available detailed project performance estimates, adequately for purpose of risk management process

Subjective assessment – process of assessing a value based on judgment, in the absence of definitive data; SMEs are often used to provide better subjective assessments

Subject Matter Experts (SMEs) – technical experts in specific areas (e.g., structures)

Tradeoff (or tradeoff value) – equivalent amounts of different project performance measures, often expressed in terms of the amount a decision maker would be willing to pay to change each project performance measure by a unit amount (e.g., $ per month of schedule)

Uncertainty – value of a particular variable is not known for certain, and might have various values

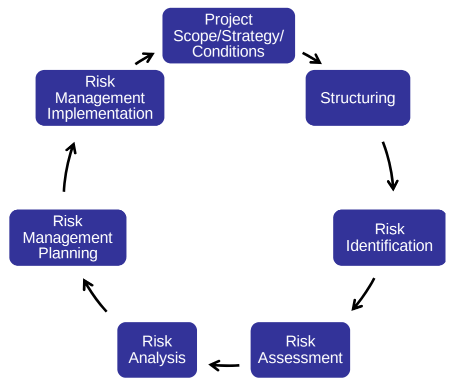
Unconditional value – value which does not depend on specific conditions being true

Unmitigated (in risk context) – before any proactive risk reduction is attempted

Variance - measure of the range of an uncertain variable (probability-weighted square of the differences relative to the mean value); square of the standard deviation

Variability – different values of a particular factor (e.g., at different times or locations), which leads to uncertainty

Module 1:
Risk Management Process



1-1

Risk Management Process

- **Learning Outcomes**
- Background
- Risk Management Definition/Benefits/Limitations
- Risk Management Process: DOT Staff
- Methods: Process and Guidance
- Discussion of DOT Applicability
- Summary

1-2

Learning Outcomes

- Identify the objectives of applying risk management
- Explain the benefits and limitations of risk management
- Describe the risk management process
- List the steps of the risk management process

1-3

Risk Management Process

- Learning Outcomes
- **Background**
- Risk Management Definition/Benefits/Limitations
- Risk Management Process: DOT Staff
- Process and Guidance
- Discussion of DOT Applicability
- Summary

1-4

Background of Risk Management Process

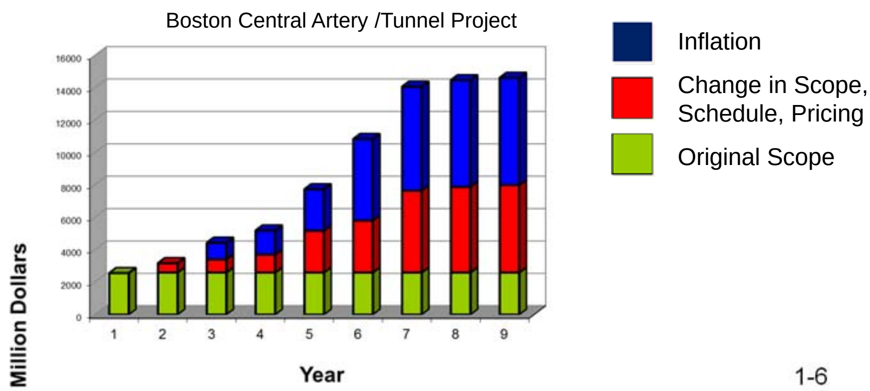
- Historically, many complex projects, experience poor "performance"
  - Exceed cost and schedule estimates
  - More disruption and less longevity than planned
- Often due to unanticipated problems (including invalid assumptions), which possibly could have been anticipated and then planned for

1-5

Why Risk Management?

Historically, widespread problem
- Project budget and schedule over-runs
- Owner-contractor-user disconnect

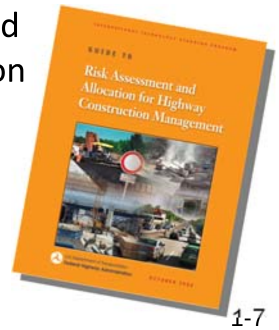
Boston Central Artery /Tunnel Project



1-6

Background of Risk Management Process

- *Solution: Formal* risk management
- Best practice since the 1970s
- Widely used by private companies and some public agencies (e.g. USCOE, FTA, FRA, WSDOT, MTA)
- FHWA (2006) “Risk Assessment and Allocation for Highway Construction Management” (*Risk Guidelines*), with training/ implementation materials
- FHWA NHI Course: 136065 Risk Management



1-7

Risk Management Process

- Learning Outcomes
- Background
- **Risk Management Definition/Benefits/Limitations**
- Risk Management Process: DOT Staff
- Process and Guidance
- Discussion of DOT Applicability
- Summary

1-8

Risk Management Process

- Formal, flexible and efficient process to
  - Identify, assess, analyze, monitor and manage project risk and opportunities
  - Anticipate and plan for potential issues and opportunities
- Better understanding and control of project outcomes

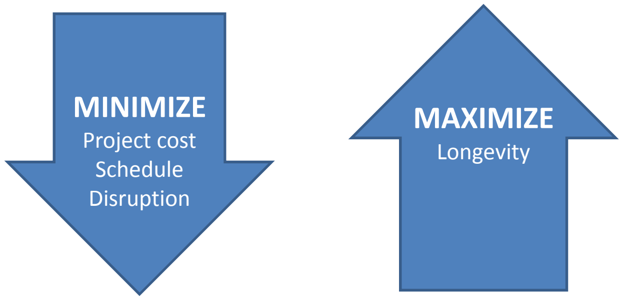
1-9

Risk/Opportunity Definition

- <u>Events</u> that *might* occur, which are outside of base assumptions and could change “base” project performance
- Risk has a negative impact (problem)
- Opportunity has a positive impact (improvement)

1-10

Risk Management Benefits



- *Disruption* (lost hours up to operations)
- *Longevity (durability)*
  - Minimize cost and disruption of <u>O&M and replacement</u>
  - Maximize time to <u>replacement</u>

1-11

Risk Management Benefits

- Is very proactive
- Puts project manager in control
- Has been shown to:
  - Decrease majority of project issues
  - Recognize substantial project cost savings
- Is "best practice"
- Is applicable to all projects and phases
- Helps project team and management to better understand project challenges/issues

1-12

Risk Management Limitations

What are some of the RM limitations?

- Could be perceived as a time-consuming process
- Requires resources and commitment
- Benefits may not be obvious

1-13

Risk Management Process

- Learning Outcomes
- Background
- Risk Management Definition/Benefits/Limitations
- **Risk Management Process: DOT Staff**
- Process and Guidance
- Discussion of DOT Applicability
- Summary

1-14

Risk Management Process DOT Staff

- DOT Risk Management Champion
- Risk Program Manager
- Risk Workshop/Meeting Facilitator
- Project Manager
- Prepared technical resources
  - Estimator
  - Scheduler
  - Project team
  - Subject Matter Experts (SMEs)

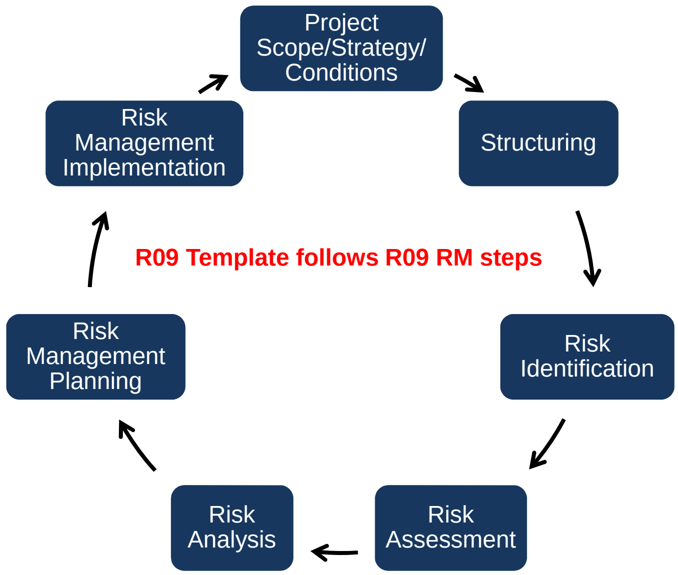
1-15

Risk Management Process

- Learning Outcomes
- Background
- Risk Management Definition/Benefits/Limitations
- Risk Management Process: DOT Staff
- **Process and Guidance**
- Discussion of DOT Applicability
- Summary

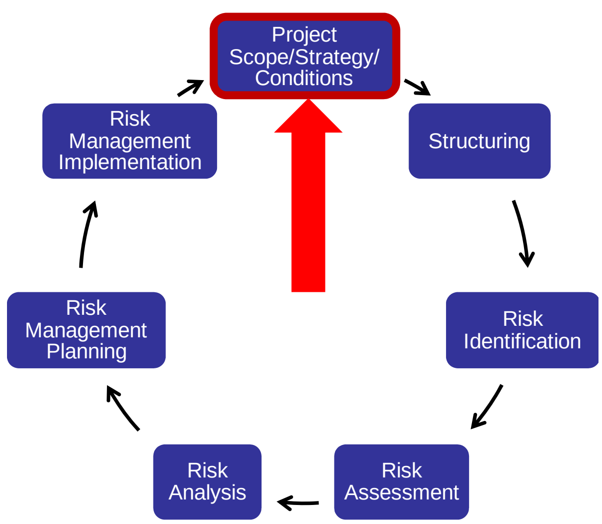
1-16

R09 Risk Management Process



1-17

R09 Risk Management Process



1-18

Project Scope, Strategy, Conditions

- Project team presents overview of project
- Understand key project elements (use established form):
  - Planned scope and alternatives
  - Planned/current status delivery and funding strategies
  - Conditions significantly affecting project
  - Major assumptions used in performance (e.g., cost, schedule) estimates
  - Latest performance estimates

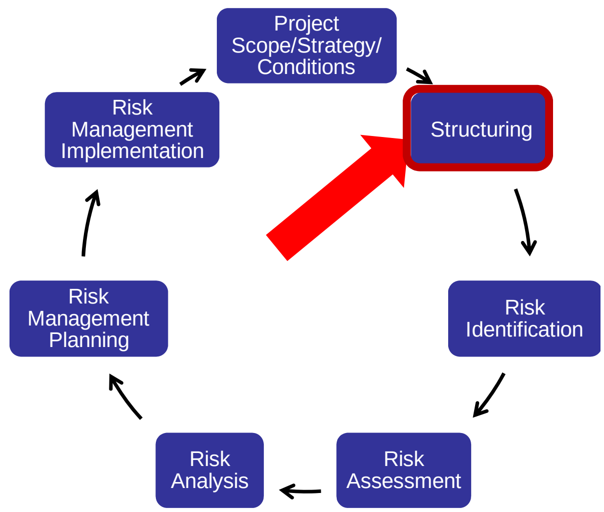
1-19

DOT Staff for Project Scope, Strategy, Conditions

- Risk Workshop/Meeting Facilitator
- DOT Project Manager
- DOT Project team (DOT staff and consultants)

1-20

R09 Risk Management Process



1-21

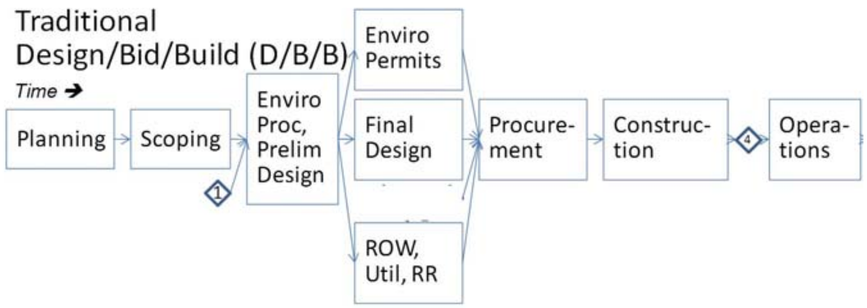
Structuring

- Risk Facilitator identifies "base" project (w/o risk, contingency, or float)
- Base project is defined by (completing established forms/template):
  - Simplified project "flow chart" (including pre-construction)
  - For each activity in project flowchart:
    - Base duration / schedule
    - Base cost
    - Base disruption
- Template does "base" performance analysis

1-22

Structuring

Standard simplified “flow chart” (on form) for risk identification and assessment for DBB or DB



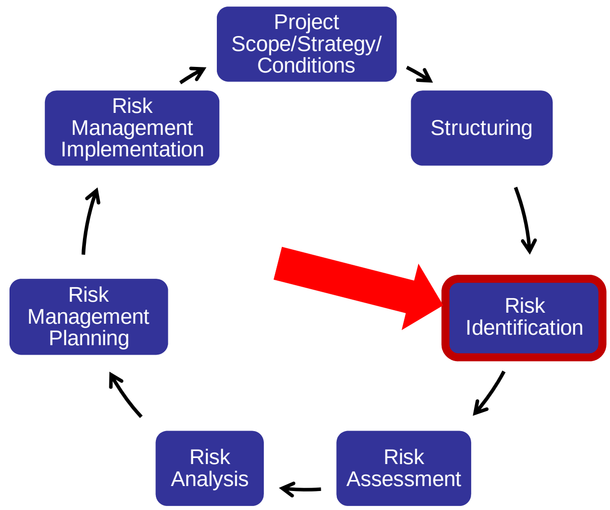
1-23

DOT Staff for Structuring

- Risk Workshop/Meeting Facilitator
- DOT Project Manager
- DOT Project team (DOT staff and consultants)

1-24

R09 Risk Management Process



1-25

Risk Identification

- Risk Facilitator identifies and documents risks and opportunities to the project's performance (e.g., delay in ROW acquisition)
- Categorize risks to ensure a comprehensive and non-overlapping set of risks by project phase (e.g. PE, ROW, UTL, Const.)
- ***Goal is to identify everything that eventually happens (as well as many things that don't)***
- **Outcome: Risk Register with tens of risks**

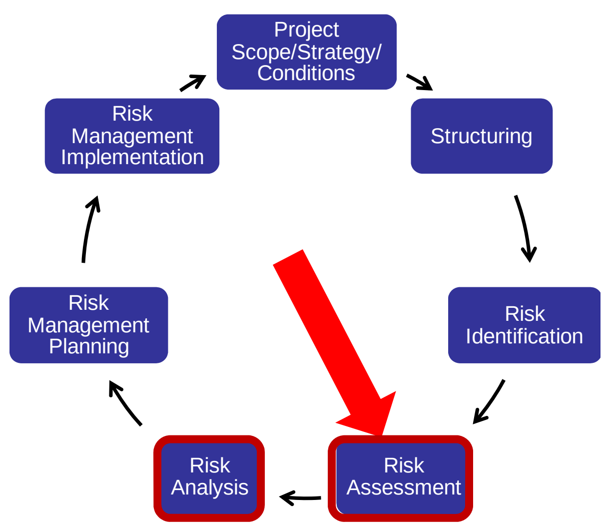
1-26

DOT Staff for Risk Identification

- Risk Workshop/Meeting Facilitator
- DOT Project Manager
- DOT Project Team (DOT staff and consultants)
- Subject Matter Experts

1-27

R09 Risk Management Process



1-28

Risk Assessment

- Once risks are identified, the Risk Facilitator with the input of the Project team and SMEs assess the:
  - Impacts (i.e. unescalated cost change, delay and additional disruption)
  - Probability of occurrence (by schedule activity)

1-29

Risk Assessment (cont.)

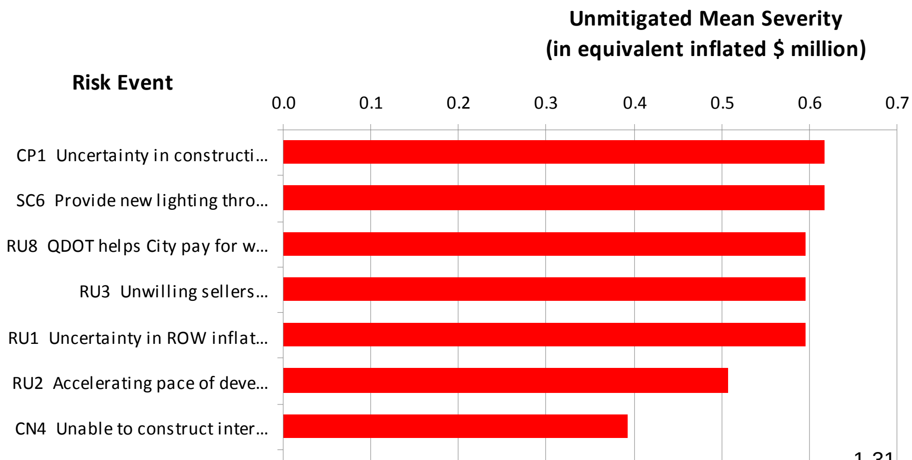
- Assessments conducted via facilitated workshop:

Quantitative Mean Ratings Method	Quantitative Mean Value method
VL, L, M, H, VH Ratings are defined with values (L= 1-3, M= 4-6, etc.)	25%, 75%, $10M, 2Mo.
Low probability of a Medium cost impact to ROW and a Low schedule impact to ROW	25% probability of a $1 million mean cost increase to ROW and a 3-month mean delay to ROW

1-30

Risk Analysis - Prioritization

Risk prioritization based on mean severity values:



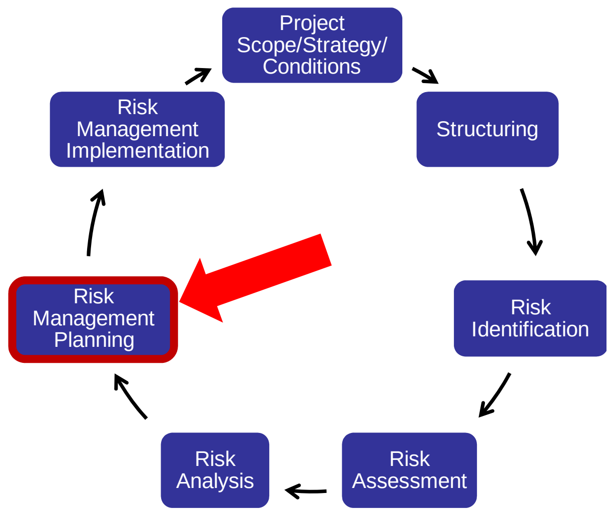
1-31

DOT Staff for Risk Assessment

- Risk Workshop/Meeting Facilitator
- Project Manager
- Project Team
- Subject Matter Experts

1-32

R09 Risk Management Process



1-33

Risk Management Planning

- Risk Facilitator with project team and SME's input identify, evaluate and plan potential actions to cost-effectively, proactively reduce key risks and exploit key opportunities
- Assess implementation impacts for each action
- Assess effectiveness of each action, in terms of mean *changes to* one or more risk factors:
  - Schedule, cost and/or disruption impact if risk occurs
  - Probability of occurrence

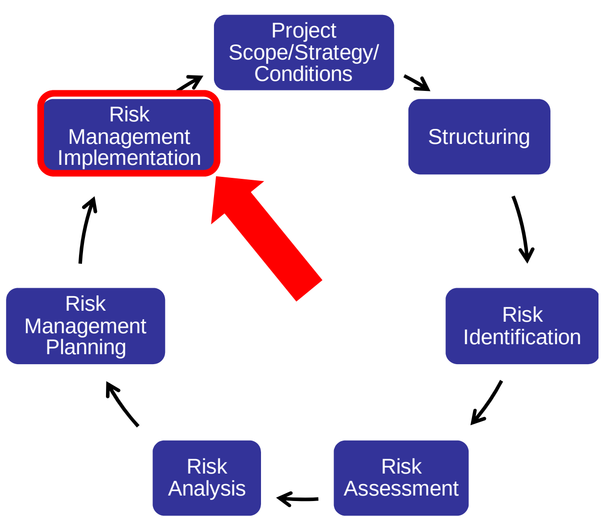
1-34

DOT Staff for Risk Management Planning

- Risk Workshop/Meeting Facilitator
- Project Manager
- Project Team
- Subject Matter Experts

1-35

R09 Risk Management Process



1-36

Process of Implementing Risk Management Plan

- *Risk Management Plan* consists of:
  – Plans for proactively reducing specific risks
  – Protocol for contingency management
  – Protocol for recovery decisions

1-37

Process of Implementing Risk Management Plan

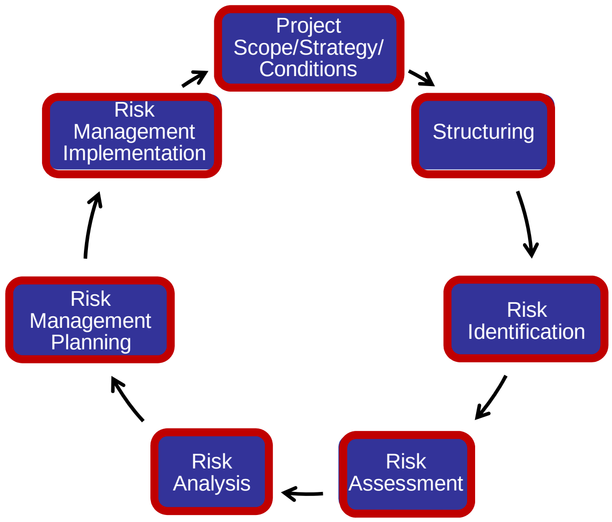
To implement plan, need to establish:

- Responsibility (e.g., project manager, risk manager)
- Authority and resources
- Commitment
- Information

Responsible DOT staff: PM + Project team

1-38

R09 Risk Management Process



1-39

Risk Management Process

- Learning Outcomes
- Background
- Definition and Benefits of Risk Management
- Risk Management Process: DOT Staff
- Process and Guidance
- **Discussion of DOT Applicability**
- Summary

1-40

Washington State DOT Example of Cost and Schedule Risk Analysis


Alaskan Way


I-90 Pass


SR520


Hood Canal

http://www.wsdot.wa.gov/projects/projectMgmt/riskAssessment

1-41

Oregon DOT Ochoco Creek Bridge Replacement, Prineville OR

42

Oregon DOT Ochoco Creek Bridge Replacement, Prineville OR

- Low-Volume State Highway (5,300 Average Daily Traffic (ADT) in 2013)
- Existing two-lane cross section without bike lanes or sidewalk
- Single span, reinforced concrete structure; 34 ft-long
- Bridge is structurally deficient
- Estimated cost:
  - $1.6M (Accelerated Bridge Construction)
  - $2.4M (staged construction)

1-43

Washington State DOT's Multi-level Risk Management Process

Project Size ($)	Required Process (project managers can use a higher level process if desired)
Less than $10 M	Qualitative Spreadsheet in the Project Management Online Guide[1]
$10 M to $25 M	In-formal workshop using the Self-Modeling Spreadsheet[1, 3]
$25 M to $100 M	Cost Risk Assessment (CRA) Workshop[1, 2]
Greater than $100 M	Cost Estimate Validation Process (CEVP®) Workshop[2]

1 In some cases it is acceptable to combine the Value Engineering Study and Risk Based Estimating Workshop.

2 Projects $25 Million and over should use the self-modeling spreadsheet in the scoping phase risk based estimating process, followed up by the more formal CRA or CEVP® process during the design phase.

3 An informal workshop is comprised of the project team (or key project team members), other participants may be included as the project manager/project team deem necessary.

A general comparison of a few typical characteristics for CRA and CEVP®

	CRA	CEVP®
Workshop length	1 – 2 days	3 – 5 days
Subject Matter Experts	Internal and local.	Internal and external.
Timing (when to hold workshop)	Anytime. Typically updated when design changes or other changes to the project warrant an updated CRA.	Best to start early in the process, major projects are typically updated as needed.
General	An assessment of risks with an evaluation and update of costs and schedule estimates.	An intense workshop that provides an external validation of cost and schedule estimates and assesses risks.

Note: Workshops are orchestrated by the Cost Risk Estimating Management (CREM) unit of the Strategic Analysis and Estimating Office in HQ in collaboration with the project manager. The project manager submits a workshop request and works with the CREM unit to ascertain the type of workshop required and candidate participants. See WSDOT Guidelines for CRA-CEVP workshops for more details.

1-44

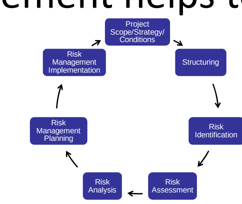
Risk Management Process

- Learning Outcomes
- Background
- Risk Management Definition/Benefits/Limitations
- Risk Management Process: DOT Staff
- Process and Guidance
- Discussion of DOT Applicability
- **Summary**

1-45

Summary - Risk Management Process

- Historically, risks affect project outcome
- Formal, structured risk management helps to:
  - Better understand possible project outcomes
  - Improve project performance



- Risk management is iterative and continuous
- Applicable to any project type and size
- R09 Template follows R09 RM steps

1-46

Questions?

goSHRP2@dot.gov

SHRP2 SOLUTIONS

Save lives. Save money. Save time.

1-47

Kosciuszko Bridge

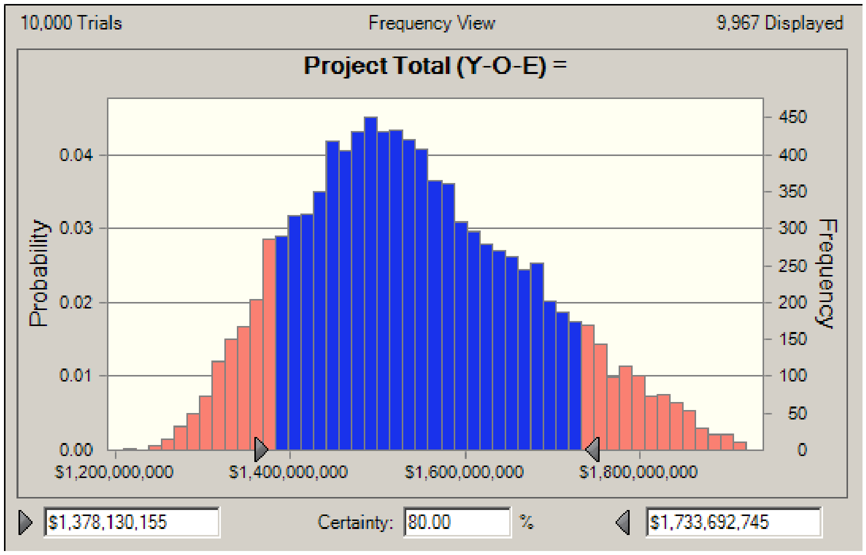
July 2008

Project Description:

The project consists of a 1.1 mile segment of the Brooklyn-Queens Expressway from Morgan Avenue in Brooklyn to the Long Island Expressway Interchange in Queens. This is one of New York City's few north-south Interstates serving a high volume of commuter and local traffic as well as a significant amount of truck traffic.

Alternative BR-5 is the projects preferred alternative which replaces the existing bridge by building two new parallel bridges on the east side. The existing bridge would then be demolished and new bridge built in its place. When completed the three new bridges would carry five EB lanes and four WB lanes with standard lane widths and shoulders. The bridges would also include a bikeway/walkway on the north side. The FEIS is expected to be issued by late summer and the ROD to be approved by October 2008.

Cost Range:



Project Benefits:

- Increase Traffic Safety
- Improve Traffic Flow
- Eliminate Structural Deficiencies

Schedule Range:

Construction Begin 2011   Construction Complete 2016

Key Project Risks:

EXAMPLES

- Potential Cemetery Impacts
- Project Funding Availability (Affects Project Schedule/Escalation)
- Third Party Coordination
- Oil Plume Impacts
- Contamination in and under Demolished Buildings
- Hazardous Material Disposal (Phelps Dodge Site)
- Archeological Finds

Financial Fine Print (including Key Assumptions):

- There are currently four proposed construction contracts which is based on funding availability.
- The current estimate is based on 2005 data.
- During the review, the current estimate was escalated by 28% to get from 2005 data to 2008 baseline.
- An escalation rate of 5.5% was applied to get from baseline to mid-year of construction.
- Project schedule is based on funding availability rather than the most efficient design and construction schedule.

What's Changed:

- This is the first cost estimate review for this project. Future workshops may be conducted as the project proceeds and when the initial Financial Plan is developed
- Due to the results of this cost estimate review, there is a strong desire to consider alternate funding methods to compress the overall project schedule to reduce costs

Level of Project Design:

Low   Medium   High

Review date:
July, 2008

"One-pager" Summary	**PROJECT NAME** **Project Location** *December 2009*	*Thumbnail project vicinity map goes here.*

Project Description

Describe the project:

What is it intended to do?
Where?
How far along is the project?
What is the current project phase?

Project Benefits

- Facilitate efficient movement of traffic through.....
- Adds capacity and enhances facilities thereby y; relieving existing and forecast congestion....
- Improves access to and from --- - -- - - -- -- -- and highway system;
- Provides essential access to the emerging - - - - - - - area.

Key Assumptions

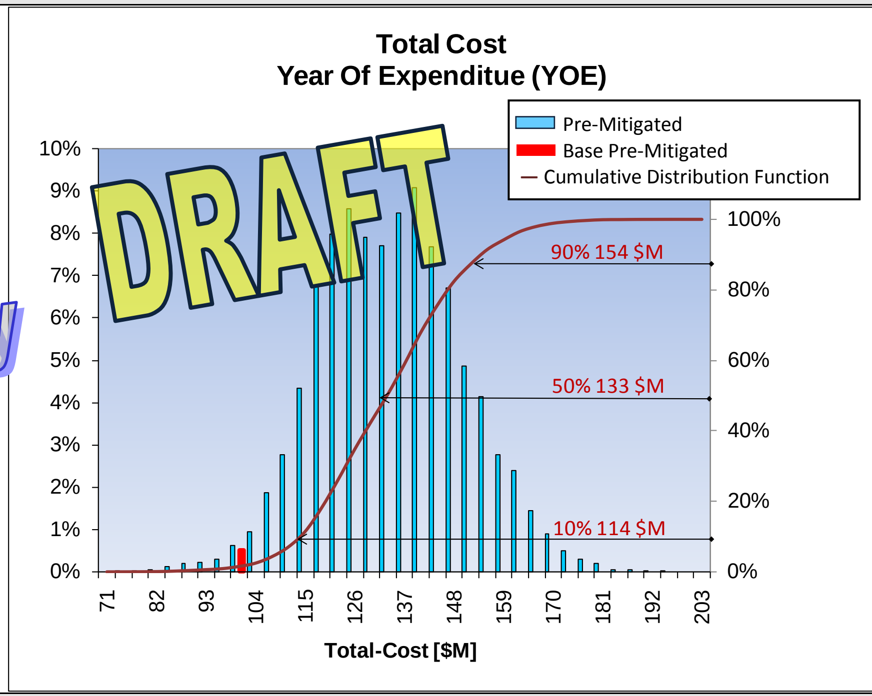
- Assumed a design-bid-build project.
- Funding is available for Preliminary Engineering, Right-Of-Way and Construction.
- Record of Decision anticipated by SEASON and YEAR.
- Design for this project is approximately 5% to 10% complete.

Project History (key dates)

<project team to provide> - examples...

- 1996 ....
- 2000....
- 2009.....

CEVP Cost Range *(opinion of cost range as of Dec 2009 project analysis)*



CEVP Schedule Range (10th to 90th %-ile)

Ad Date	*06/2014 to 07/2015*	*Probable ad date and completion date analysis of project in January 2010.*
Construction Complete	*11/2016 to 02/2018*	

Key Project Cost Risks (estimated ~most likely impact value)

%p	***Threats***
95	ROW Plan delay, (~$3 M)
50	Higher PE costs (~$4 M)
40/20	ACME accommodations (~$1 M/~$7)
20	Partial R/W acquisitions become full takes (~$6M)
75	RR Crossing foundation/alignment concerns (~$1 M)
	Opportunities
20/10	Design near 42nd Av connection (~$2 M/~$12 M savings)

Key Project Schedule Risks (estimated ~most likely impact value)

%p	***Threats***
95	ROW Plan delay, (~12 months)
75	Construction delays – cumulative (~5 months)
25	NEPA challenges (~12 months)
20	Partial R/W acquisitions become full takes (~6 months)

Level of Project Design	Low — Medium — High	December 2009	WSDOT

1-5 Statement of Policy

1-5.1 Project Risk Management and Risk-Based Estimating

It is WSDOT's policy to conduct risk-based estimating workshops for all projects over $10 million (PE, R/W, and Const). These workshops provide information to Project Managers that can help them control scope, cost, and schedule, and manage risks for all projects (Exhibit 1-3). This policy reaffirms the requirement that a Risk Management Plan is a component of every Project Management Plan.

Exhibit 1-3 Levels of Risk-Based Estimating, in Support of Risk Management (E 1053)

Project Size ($M)	Required Process*
Less than $10M	Qualitative spreadsheet in the *Project Management Online Guide*[1]
$10M to $25M	Informal workshop using the self-modeling spreadsheet[1][3]
$25M to $100M	Cost Risk Assessment (CRA) workshop[1][2]
Greater than $100M	Cost Estimate Validation Process® (CEVP®) workshop[2]

[1] In some cases, it is acceptable to combine a Value Engineering Study with a Risk-Based Estimating Workshop.

[2] Projects $25 million and over should use the self-modeling spreadsheet in the scoping phase of the risk-based estimating process, followed up by the more formal CRA or CEVP® process during the design phase.

[3] An informal workshop is composed of the project team (or key project team members); other participants may be included as the Project Manager/project team deem necessary.

*Project Managers can use a higher-level process if desired.

1-6 Project Risk Management Planning

Great project risk management requires good planning. Begin with proven project management practices: review organizational policies and guidance; initiate and align the project team; and follow the steps provided in the *Project Management Online Guide*. Risk management must commence early in project development and proceed as the project evolves and project information increases in quantity and quality. Plan to:

- Identify, assess/analyze, and respond to major risks.
- Continually monitor project risks and response actions.
- Conduct an appropriate number and level of risk assessments to update the Risk Management Plan and evolving risk profile for the project.

Consider the resources needed for project risk management and build them into the project development budget and schedule. Risk management activities, including events such as Cost Risk Assessment (CRA), Cost Estimate Validation Process (CEVP®), Value Engineering – Risk Assessment (VERA), or other meetings, need to be part of the project work plan and built into the project schedule and budget (Exhibit 1-4).

Exhibit 1-4 General Comparison of a Few Typical Characteristics of CRA and CEVP®

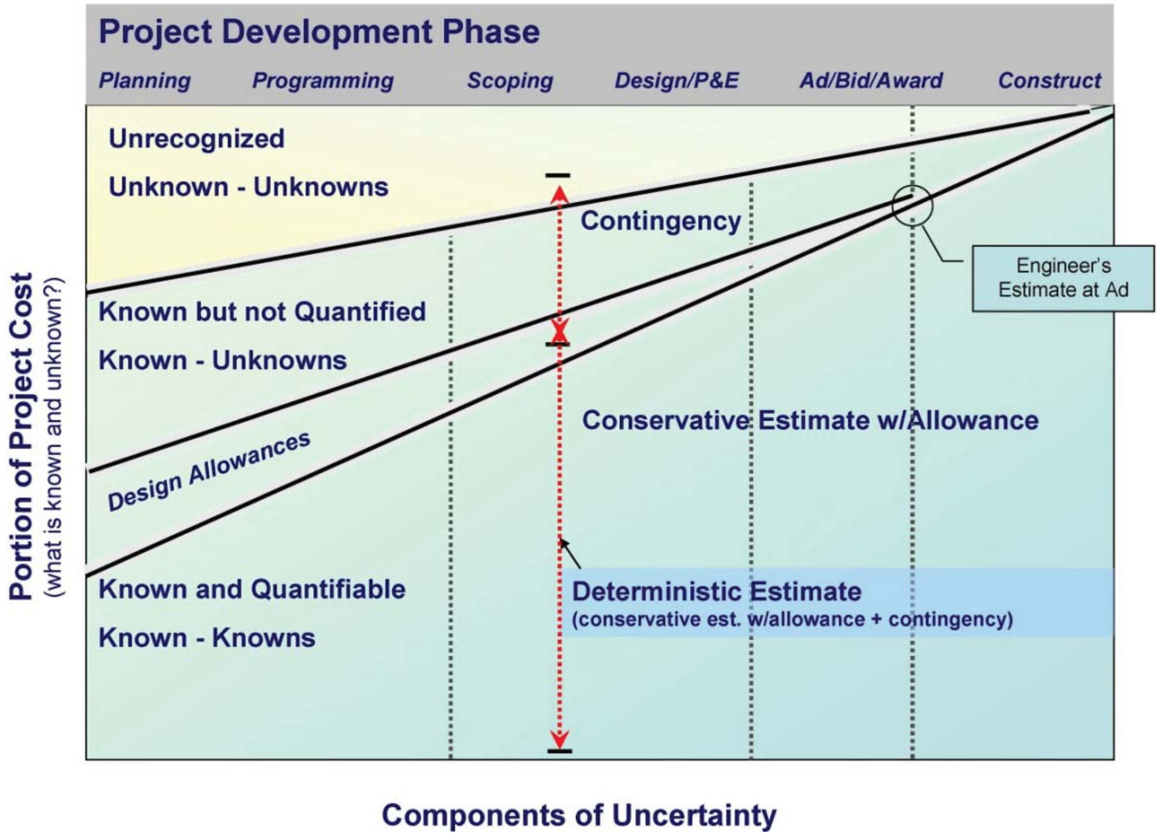
Details	CRA	CEVP®
Typical Length	1 – 2 days	3 – 5 days
Subject Matter Experts	Internal and local.	Internal and external.
Timing	Any time; typically updated when design changes or other changes to the project warrant an updated CRA.	It is best to start early in the process; major projects are typically updated as needed.
General	An assessment of risks with an evaluation and update of costs and schedule estimates.	An intense workshop that provides an external validation of cost and schedule estimates and assesses risks.
Note: Risk assessments are orchestrated by the Cost Risk Estimating Management (CREM) Unit of the Strategic Analysis and Estimating Office at Headquarters, in collaboration with the Project Manager. The Project Manager submits a workshop request and works with the CREM Unit to ascertain the type of workshop required and the candidate participants. (See Part II: Guidelines for CRA-CEVP® Workshops for more details.)		

Exhibit 1-5 illustrates how project information develops and evolves over time. With rising project knowledge comes an understanding that contending with some elements of the project will require significant additional resources. These elements could involve: scope; environmental mitigation and permitting; rising cost of right of way as corridors develop in advance of the project; utilities; seismic issues; and other elements.

In the past, traditional estimating practices tended to produce “the number” for a project; but the single number masks the critical uncertainty inherent in a particular project. It implies a sense of precision beyond what can be achieved during planning, scoping, or early design phases.

We recognize that an estimate is more accurately expressed as a range, not as a single number. To determine an accurate estimate range for both cost and schedule, risk must be measured. Formerly, WSDOT measured risk based on the estimator’s experience and best judgment, without explicitly identifying the project’s uncertainties and risks. That has changed. Estimates are now composed of two components: the base cost component and the risk (or uncertainty) component. The base cost represents the cost that can reasonably be expected if the project materializes as planned. The base cost does not include contingencies. Once the base cost is established, a list of risks is created of opportunities and threats, called a “risk register.” The risk assessment replaces general and vaguely defined contingency with explicitly defined risk events. Risk events are characterized in terms of probability of occurrence and the consequences of each potential risk event.

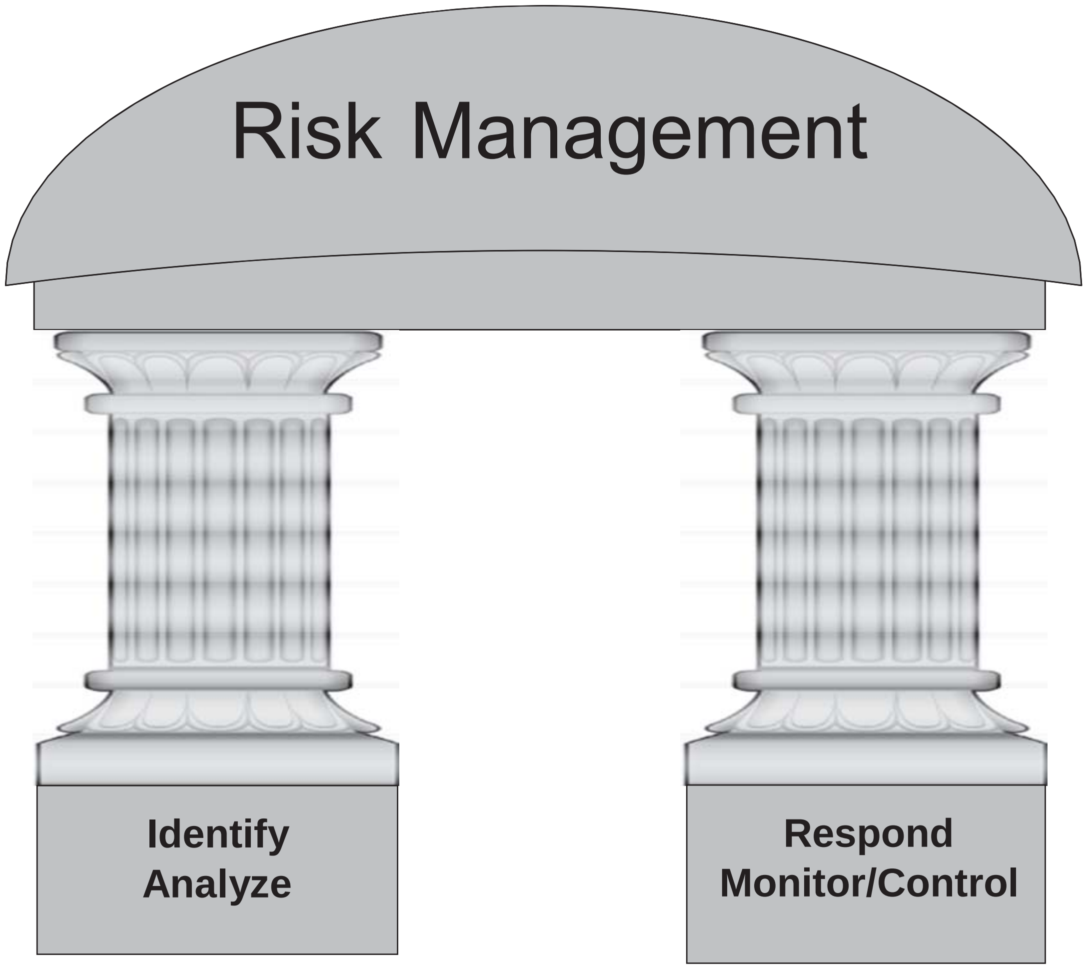
Exhibit 1-5 Evolution of Project Knowledge Through Project Development



Executive Order (EO) E 1053 instructs employees to actively manage their projects. EO E 1038 establishes, as policy, that WSDOT is to proactively assess and respond to any risks that may affect the achievement of the department's strategic performance-based objectives and their intended outcomes. It further goes on to direct employees to support the department's efforts to identify, share, and manage risk across all organizations and functions.

Risk reviews are an integral part of budget development, with the intent that the department makes informed decisions about risk tolerance. It can be inferred that determined Enterprise Risk Management includes comprehensive project risk management Project risk management is a major element in the Project Management Plan, which is required for all WSDOT projects (EO E 1032). We, as stewards of the public trust, must endeavor to inform decision makers of the uncertainty and risk associated with the projects we develop. We must understand risk tolerance and we must weigh the value of project decisions against project risks.

Chapter 5 of the book *Risk, Uncertainty and Government* notes, "…lawyers and economists are accustomed to think of contracts for future performance as devices for allocating risks of future events." In order for us to understand this allocation of risk, projects must be examined and the uncertainty and risks must be documented and characterized.



We can think of risk management as two pillars (depicted above). They are: "IDENTIFY and ANALYZE" the risks, then, "RESPOND, MONITOR, and CONTROL" project risk.

Unless we incorporate the second pillar, we are not realizing the full value of risk management. When preparing the Project Management Plan and work activities for our project, we must include both pillars of risk management.

STRATEGIC HIGHWAY RESEARCH PROGRAM

Module 2: Introduction to R09 Risk Management Template

U.S. Department of Transportation Federal Highway Administration

THE VOICE OF TRANSPORTATION

TRANSPORTATION RESEARCH BOARD OF THE NATIONAL ACADEMIES

2-1

Learning Outcomes

- Identify the steps of the R09 risk management template
- Explain the relation between the steps of the R09 process and the steps of the R09 risk management template

2-2

Risk Management Template Steps

Template Sections	Description	Course Module
HOME Screen	Enter Agency, project location, project name, project manager name, risk workshop facilitator name. Access to summary report and project reset	N/A
Step 1 - Project Structuring	Enter Base Project Information (schedule, cost, disruption, etc.)	Modules 3- Project Scope, Strategy and Conditions Module 4- Structuring
Step 2 - Risk Identification	Create list of potential risks and opportunities	Module 5- Risk Identification
Step 3 - Rating Scale	Enter values for scales used to assess risk probability and cost, schedule and disruption impacts	Module 6- Risk Assessment
Step 4 - Unmitigated Risk Assessment	Assess risk's probability and cost, schedule and disruption impacts	
Step 5 - Unmitigated Risk Register	View unmitigated risks ranked by mean severity value	

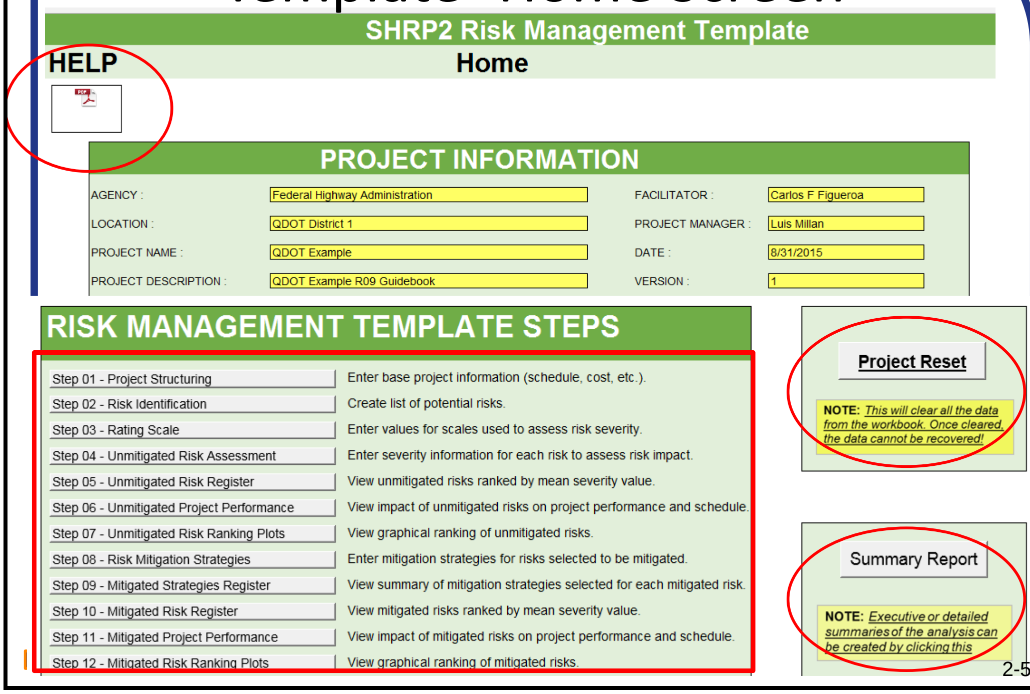
2-3

Risk Management Template Steps (cont.)

Template Sections	Description	Course Module
Step 6 - Unmitigated Project Performance	View impact of unmitigated risks on project performance (cost ,schedule, disruption)	Module 6- Risk Assessment
Step 7 – Unmitigated Risk Ranking Plots	View graphical ranking of unmitigated risks	
Step 8 - Risk Mitigation Strategies	Enter mitigation strategies for most severe risks, as selected	Module 7- Risk Management Planning Module 8 – Implementing the Risk Management Plan
Step 9 –Mitigation Strategies Register	View summary of mitigation strategies selected for each mitigated risk	
Step 10 – Mitigated Risk Register	View mitigated risks ranked by mean severity value	
Step 11 – Mitigated Project Performance	View impact of mitigated risks on project performance (cost, schedule, disruption)	
Step 12 - Mitigated Risk Ranking Plots	View graphical ranking of mitigated risks	
Summary Report	Summary tables with results for each template step	N/A

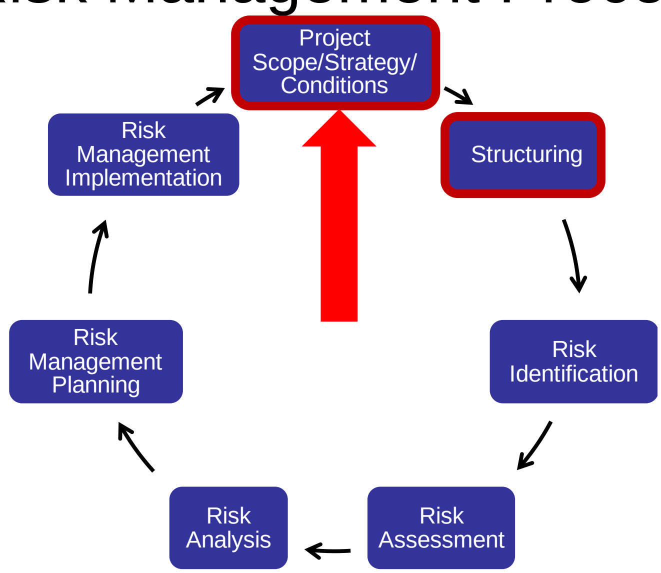
2-4

Template- Home Screen



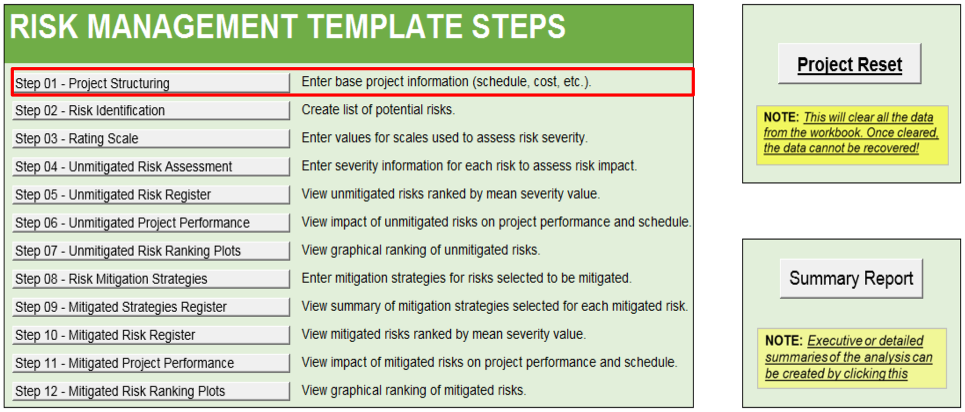
2-5

Risk Management Process



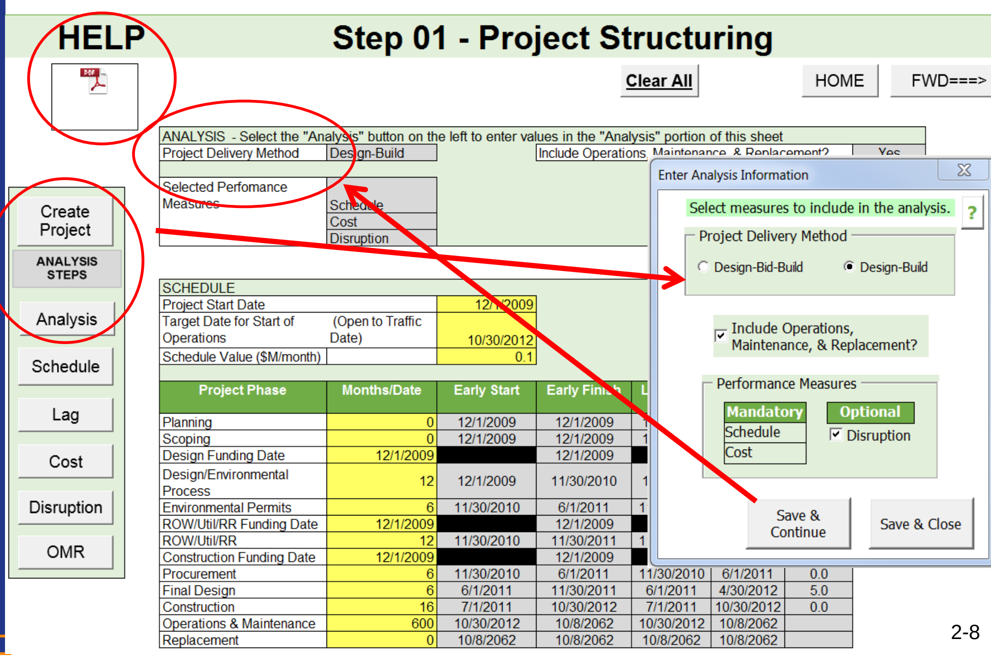
2-6

Template Step 1 - Structuring



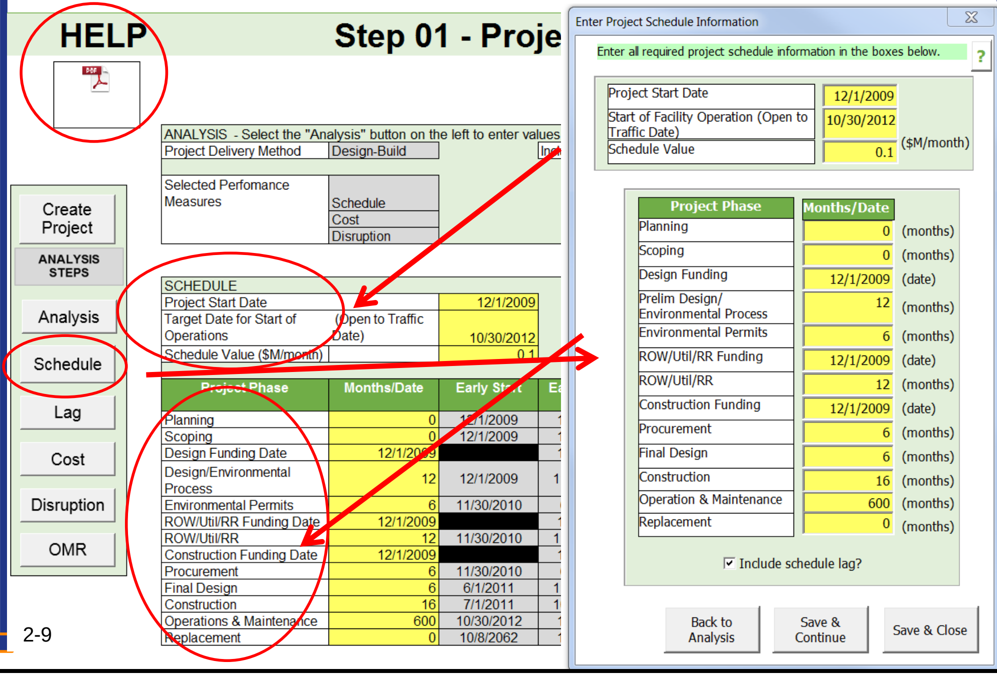
2-7

Template Step 1- Structuring (cont.)



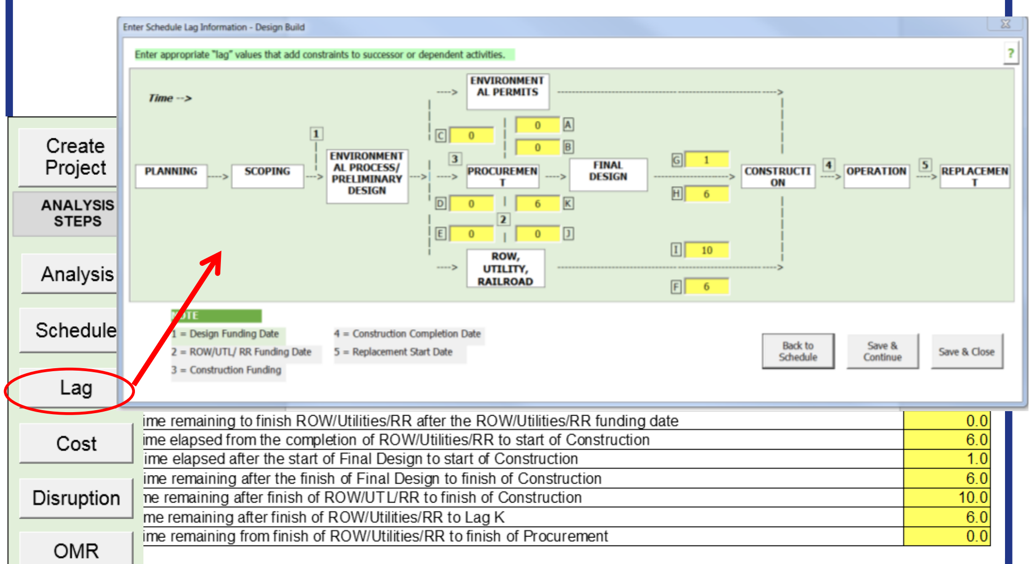
2-8

Template Step 1- Structuring (cont.)



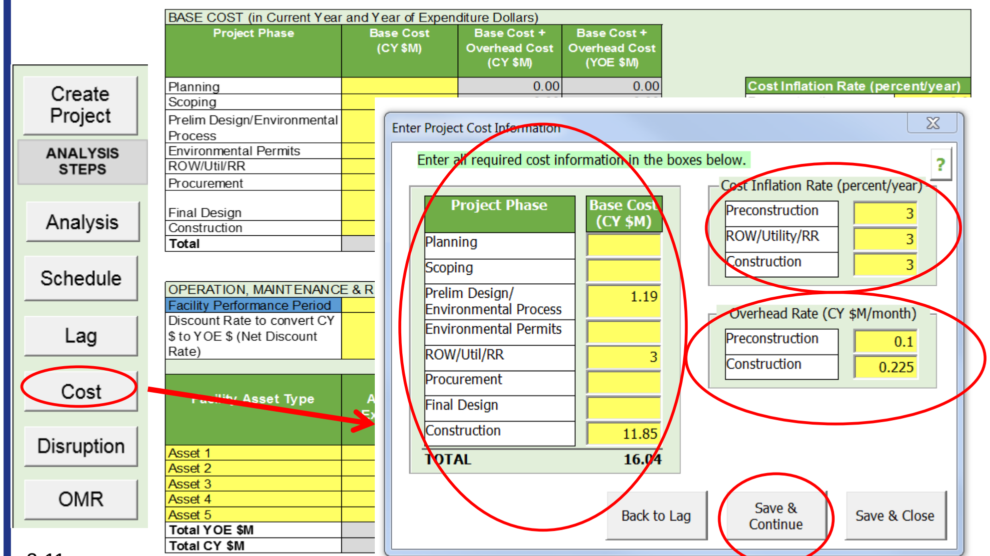
2-9

Template Step 1- Structuring (cont.)

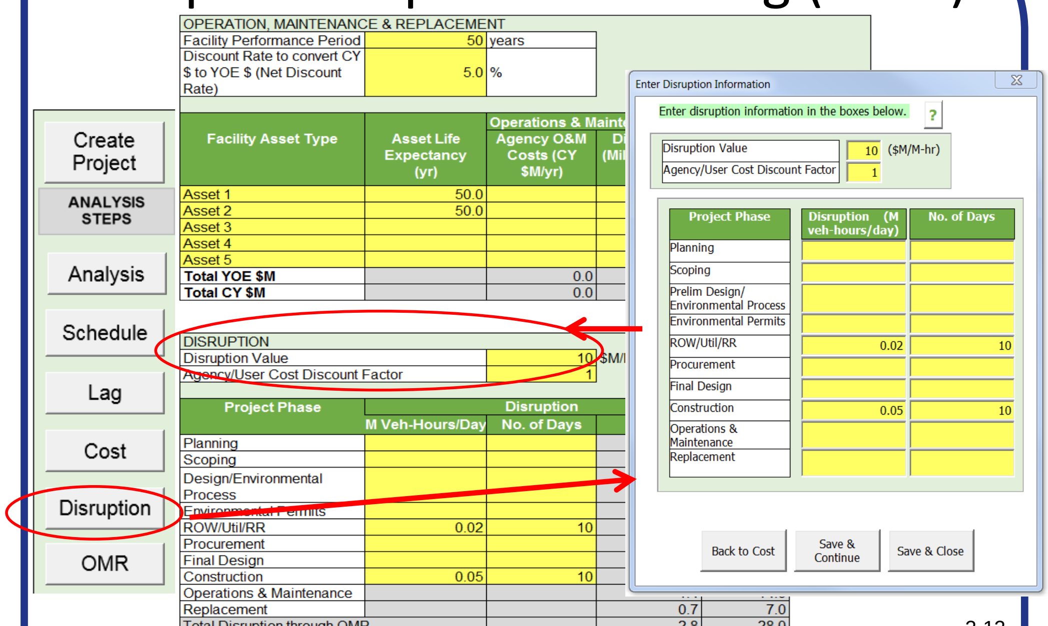


2-10

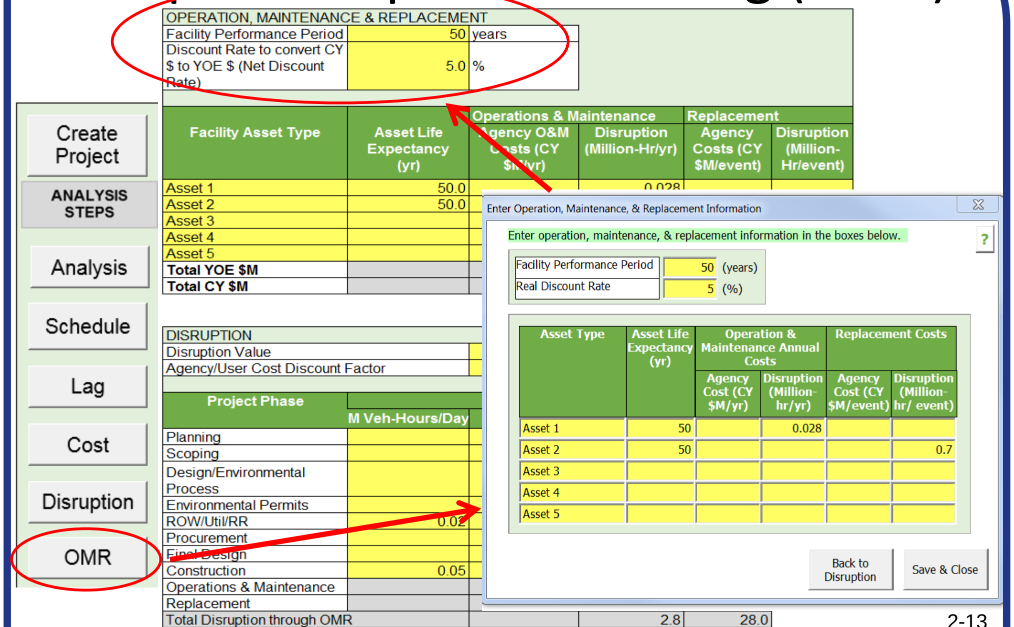
Template Step 1- Structuring (cont.)



Template Step 1- Structuring (cont.)



Template Step 1- Structuring (cont.)



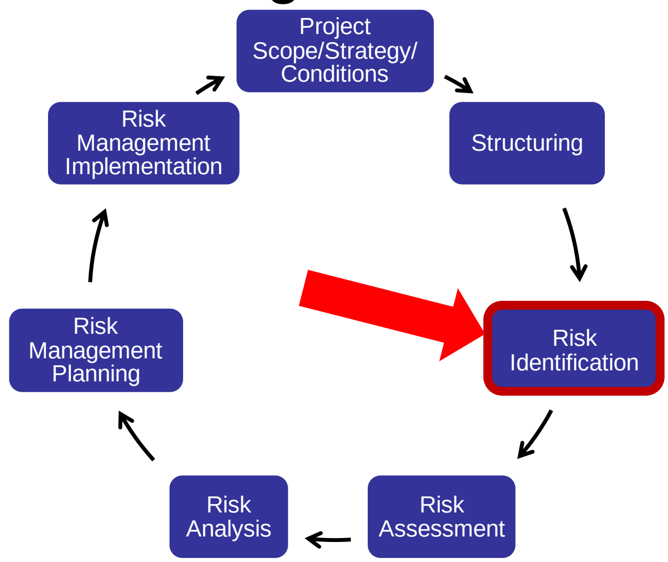
2-13

Template Step 1- Structuring (cont.)

SUMMARY					
Project Phase	**Total CY Cost ($M)**	**Total YOE Cost ($M)**	**Duration (months)**	**Early Start**	**Early Finish**
Planning		0.00	0	12/1/2009	12/1/2009
Scoping		0.00	0	12/1/2009	12/1/2009
Design/Environmental Process	1.19	1.21	12	12/1/2009	11/30/2010
Environmental Permits		0.00	6	11/30/2010	6/1/2011
ROW/Util/RR	3.00	3.14	12	11/30/2010	11/30/2011
Final Design		0.00	6	6/1/2011	11/30/2011
Procurement		0.00	6	11/30/2010	6/1/2011
Construction	11.85	12.67	16	7/1/2011	10/30/2012
Operations & Maintenance	0.00	0.00	600	10/30/2012	10/30/2062
Replacement	0.00	0.00	0	10/30/2062	
Base Cost (YOE $M)	17.02	(through Operations, Maintenance, & Replacement)			
Base Construction Completion Date	10/30/2012				
Months to Construction Completion	35.00				
Base Disruption ($M)	18.70	(through Operations, Maintenance, & Replacement)			

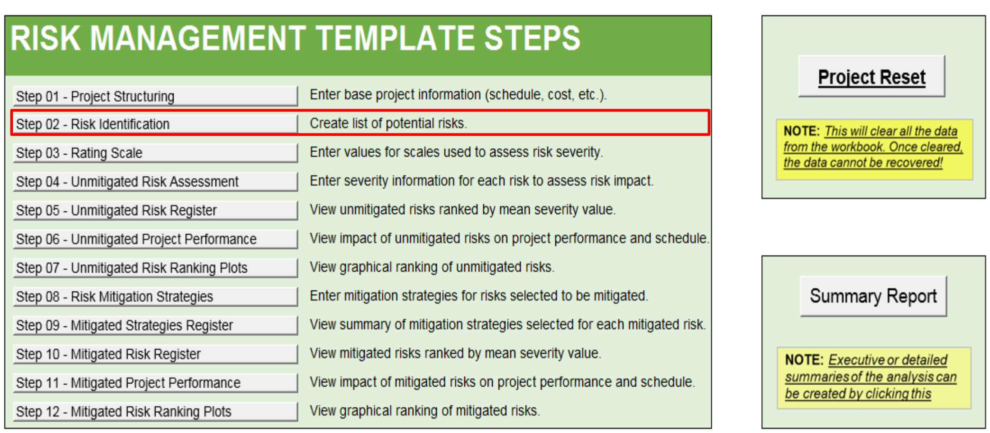
2-14

Risk Management Process



2-15

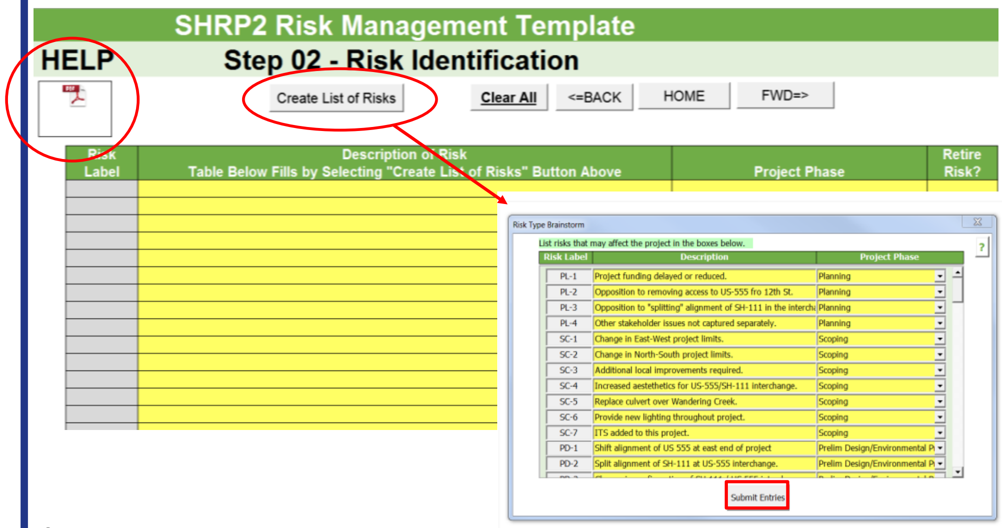
Template Step 2- Risk Identification



RISK MANAGEMENT TEMPLATE STEPS	
Step 01 - Project Structuring	Enter base project information (schedule, cost, etc.).
Step 02 - Risk Identification	Create list of potential risks.
Step 03 - Rating Scale	Enter values for scales used to assess risk severity.
Step 04 - Unmitigated Risk Assessment	Enter severity information for each risk to assess risk impact.
Step 05 - Unmitigated Risk Register	View unmitigated risks ranked by mean severity value.
Step 06 - Unmitigated Project Performance	View impact of unmitigated risks on project performance and schedule.
Step 07 - Unmitigated Risk Ranking Plots	View graphical ranking of unmitigated risks.
Step 08 - Risk Mitigation Strategies	Enter mitigation strategies for risks selected to be mitigated.
Step 09 - Mitigated Strategies Register	View summary of mitigation strategies selected for each mitigated risk.
Step 10 - Mitigated Risk Register	View mitigated risks ranked by mean severity value.
Step 11 - Mitigated Project Performance	View impact of mitigated risks on project performance and schedule.
Step 12 - Mitigated Risk Ranking Plots	View graphical ranking of mitigated risks.

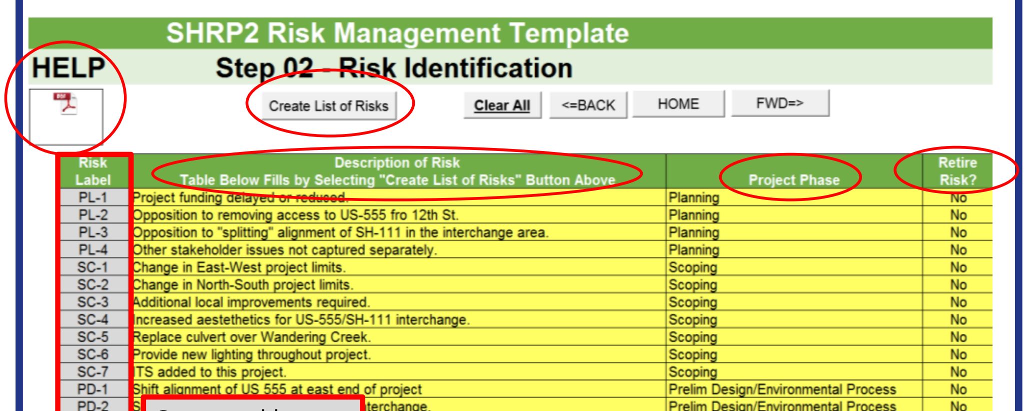
2-16

Template Step 2- Risk Identification (cont.)



2-17

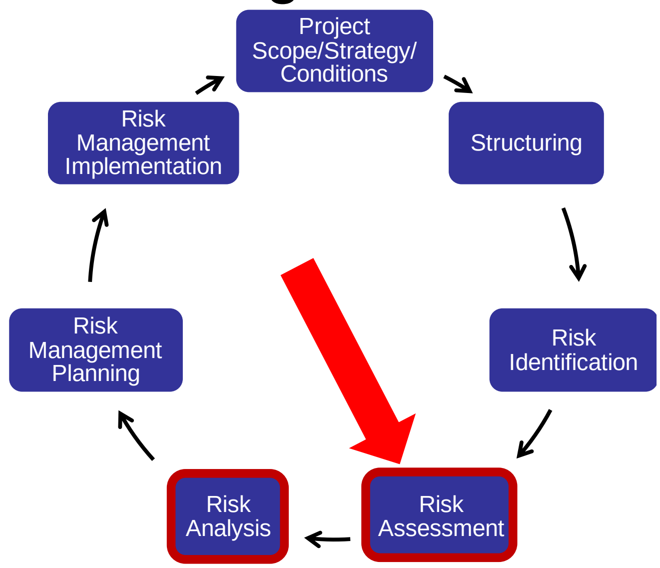
Template Step 2- Risk Identification (cont.)



Generated by template once risks are categorized

2-18

Risk Management Process



2-19

Template Step 3- Rating Scale

RISK MANAGEMENT TEMPLATE STEPS

Step 01 - Project Structuring	Enter base project information (schedule, cost, etc.).
Step 02 - Risk Identification	Create list of potential risks.
Step 03 - Rating Scale	Enter values for scales used to assess risk severity.
Step 04 - Unmitigated Risk Assessment	Enter severity information for each risk to assess risk impact.
Step 05 - Unmitigated Risk Register	View unmitigated risks ranked by mean severity value.
Step 06 - Unmitigated Project Performance	View impact of unmitigated risks on project performance and schedule.
Step 07 - Unmitigated Risk Ranking Plots	View graphical ranking of unmitigated risks.
Step 08 - Risk Mitigation Strategies	Enter mitigation strategies for risks selected to be mitigated.
Step 09 - Mitigated Strategies Register	View summary of mitigation strategies selected for each mitigated risk.
Step 10 - Mitigated Risk Register	View mitigated risks ranked by mean severity value.
Step 11 - Mitigated Project Performance	View impact of mitigated risks on project performance and schedule.
Step 12 - Mitigated Risk Ranking Plots	View graphical ranking of mitigated risks.

Project Reset

NOTE: *This will clear all the data from the workbook. Once cleared, the data cannot be recovered!*

Summary Report

NOTE: *Executive or detailed summaries of the analysis can be created by clicking this*

2-20

Template Step 3- Rating Scale (cont.)

- Rating Scales for risk Cost change ($M), Schedule change (months), Disruption change (million-hrs) and probability of occurrence

HELP

Step 03 - Rating Scale

Create Rating Scale | Clear All | <=== BACK | HOME | FWD ===>

Base Cost through Construction	16.04	(CY $M)
Base Schedule	35	Months
Base Disruption through Construction	0.70	M-Hr
Data Entry Type	Percent	

COST CHANGE

Adjectival Rating	Percent of Base Cost		Absolute Value (CY $M)		Expected Mean Value	
	Low	High	Low	High	Percent	Absolute
VH	24.94	49.88	4.00	8.00	37.41	6.00
H	9.98	24.94	1.60	4.00	17.46	2.80
M	3.12	9.98	0.50	1.60	6.55	1.05
L	1.25	3.12	0.20	0.50	2.18	0.35
VL	0.00	1.25	0.00	0.20	0.62	0.10

DURATION CHANGE

Adjectival Rating	Percent of Base Schedule		Absolute Value (months)		Expected Mean Value	
	Low	High	Low	High	Percent	Absolute
VH	34.29	68.57	12.00	24.00	51.43	18.00
H	11.43	34.29	4.00	12.00	22.86	8.00
M	2.86	11.43	1.00	4.00	7.14	2.50
L	0.71	2.86	0.25	1.00	1.79	0.63
VL	0.00	0.71	0.00	0.25	0.36	0.13

2-21

Template Step 3- Rating Scale (cont.)

DISRUPTION CHANGE

Adjectival Rating	Percent of Base Disruption		Absolute Value (M person-Hrs)		Expected Mean Value	
	Low	High	Low	High	Percent	Absolute
VH	28.57	57.14	0.20	0.40	42.86	0.30
H	14.29	28.57	0.10	0.20	21.43	0.15
M	0.00	14.29	0.00	0.10	7.14	0.05
L	0.00	0.00	0.00	0.00	0.00	0.00
VL	0.00	0.00	0.00	0.00	0.00	0.00

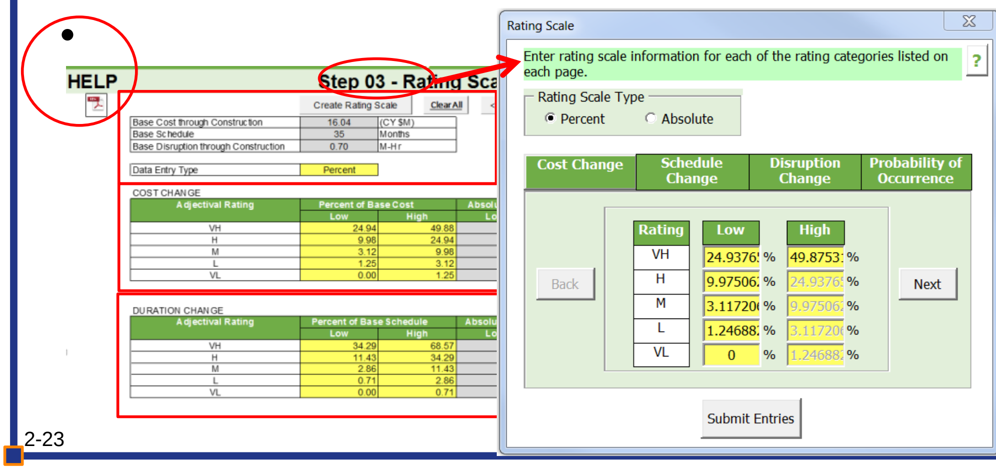
PROBABILITY OF OCCURRENCE

Adjectival Rating	Probability Range		Mean Probability
	Low	High	
VH	0.70	1.00	0.85
H	0.40	0.70	0.55
M	0.20	0.40	0.30
L	0.05	0.20	0.13
VL	0.00	0.05	0.03

2-22

Template Step 3- Rating Scale (cont.)

- Rating Scales for risk Cost change ($M), Schedule change (months), Disruption change (million-hrs) and probability of occurrence
-



2-23

Template Step 4- Unmitigated Risk Assessment

RISK MANAGEMENT TEMPLATE STEPS

Step 01 - Project Structuring	Enter base project information (schedule, cost, etc.).
Step 02 - Risk Identification	Create list of potential risks.
Step 03 - Rating Scale	Enter values for scales used to assess risk severity.
Step 04 - Unmitigated Risk Assessment	Enter severity information for each risk to assess risk impact.
Step 05 - Unmitigated Risk Register	View unmitigated risks ranked by mean severity value.
Step 06 - Unmitigated Project Performance	View impact of unmitigated risks on project performance and schedule.
Step 07 - Unmitigated Risk Ranking Plots	View graphical ranking of unmitigated risks.
Step 08 - Risk Mitigation Strategies	Enter mitigation strategies for risks selected to be mitigated.
Step 09 - Mitigated Strategies Register	View summary of mitigation strategies selected for each mitigated risk.
Step 10 - Mitigated Risk Register	View mitigated risks ranked by mean severity value.
Step 11 - Mitigated Project Performance	View impact of mitigated risks on project performance and schedule.
Step 12 - Mitigated Risk Ranking Plots	View graphical ranking of mitigated risks.

Project Reset

NOTE: *This will clear all the data from the workbook. Once cleared, the data cannot be recovered!*

Summary Report

NOTE: *Executive or detailed summaries of the analysis can be created by clicking this*

2-24

Template Step 4- Unmitigated Risk Assessment (cont.)

SHRP2 Risk Management Template

HELP

Step 04 - Unmitigated Risk Assessment

Conduct Risk Assessment | Calculate Mean Severity Values | Clear All | <=== BACK | HOME | FWD===>

Risk Label	Risk Description	Probability of Occurrence			Mean Cost Change (CY $M)					Mean Duration Change (months)					
		Adjectival	Numerical	Mean Value	Risk Type	Adjectival	Numerical	Mean Value	Affected Phase	Risk Type	Adjectival	Numerical	Mean Value	Affected Phase	Risk Type
PL-1	Project funding delayed or reduced.			0.00				0.00					0.00		
PL-2	Opposition to removing access to US-555 fro 12th St.	L		0.13	Threat	VL		0.10	Construction			0.00	0.00		
PL-3	Opposition to "splitting" alignment of SH-111 in the interchange area.			0.00				0.00					0.00		
PL-4	Other stakeholder issues not captured separately.			0.00				0.00					0.00		
SC-1	Change in East-West project limits.			0.00				0.00					0.00		
SC-2	Change in North-South project limits.			0.00				0.00					0.00		
SC-3	Additional local improvements required.	M		0.30	Threat	L		0.35	Construction	Threat	L		0.63	Prelim Design/Environmental Process	
SC-4	Increased aestethetics for US-555/SH-111 interchange.			0.00				0.00					0.00		
SC-5	Replace culvert over Wandering Creek.	M		0.30	Threat	L		0.35	Construction			0.00	0.00		
SC-6	Provide new lighting throughout project.	H		0.55	Threat	M		1.05	Construction			0.00	0.00		
SC-7	ITS added to this project.			0.00				0.00					0.00		
PD-1	Shift alignment of US 555 at east end of project	VL		0.03	Threat	M		1.05	ROW/Util/RR	Threat	M		2.50	ROW/Util/RR	
PD-2	Split alignment of SH-111 at US-555 interchange.			0.00				0.00					0.00		

2-25

Template Step 4- Unmitigated Risk Assessment (cont.)

SHRP2 Risk Management Template

HELP

Step 04 - Unmitigated Risk Assessment

Conduct Risk Assessment | Calculate Mean Severity Values | Clear All | <=== BACK | HOME | FWD===>

Risk Assessment

Enter information about each risk shown below.

NOTE: If both Adjectival and Numerical inputs are left blank, a value of 0 is assumed.

RISK		PROBABILITY OF OCCURENCE		MEAN COST CHANGE			
		Likelihood Rating		Severity Rating			
Risk Label	Risk Description	Adjectival	Numerical	Risk Type	Adjectival	Numerical	Affected Phase
PL-1	Project funding delayed or reduced.						
PL-2	Opposition to removing access to US-555 fro 12th St.	L		Threat	VL		Construction
PL-3	Opposition to "splitting" alignment of SH-111 in the interchange						
PL-4	Other stakeholder issues not captured separately.						
SC-1	Change in East-West project limits.						
SC-2	Change in North-South project limits.						
SC-3	Additional local improvements required.	M		Threat	L		Construction
SC-4	Increased aestethetics for US-555/SH-111 interchange.						
SC-5	Replace culvert over Wandering Creek.	M		Threat	L		Construction
SC-6	Provide new lighting throughout project.	H		Threat	M		Construction

Previous | Next | Save & Close

2-26

Template Step 4- Unmitigated Risk Assessment (cont.)

SHRP2 Risk Management Template

HELP

Step 04 - Unmitigated Risk Assessment

Conduct Risk Assessment | Calculate Mean Severity Values | Clear All | <=== BACK | HOME | FWD===>

Risk		Probability of Occurrence			Mean Cost Change (CY $M)					Mean Duration Change (months)					
Label	Risk Description	Adjectival	Numerical	Mean Value	Risk Type	Adjectival	Numerical	Mean Value	Affected Phase	Risk Type	Adjectival	Numerical	Mean Value	Affected Phase	Risk Type
PL-1	Project funding delayed or reduced.			0.00				0.00					0.00		
PL-2	Opposition to removing access to US-555 fro 12th St.	L		0.13	Threat	VL		0.10	Construction			0.00	0.00		
PL-3	Opposition to "splitting" alignment of SH-111 in the interchange area.			0.00				0.00					0.00		
PL-4	Other stakeholder issues not captured separately.			0.00				0.00					0.00		
SC-1	Change in East-West project limits.			0.00				0.00					0.00		
SC-2	Change in North-South project limits.			0.00				0.00					0.00		
SC-3	Additional local improvements required.	M		0.30	Threat	L		0.35	Construction	Threat	L		0.63	Prelim Design/Environmental Process	
SC-4	Increased aestethetics for US-555/SH-111 interchange.			0.00				0.00					0.00		
SC-5	Replace culvert over Wandering Creek.	M		0.30	Threat	L		0.35	Construction			0.00	0.00		
SC-6	Provide new lighting throughout project.	H		0.55	Threat	M		1.05	Construction			0.00	0.00		
SC-7	ITS added to this project.			0.00				0.00					0.00		
PD-1	Shift alignment of US 555 at east end of project	VL		0.03	Threat	M		1.05	ROW/Util/RR	Threat	M		2.50	ROW/Util/RR	
PD-2	Split alignment of SH-111 at US-555 interchange.			0.00				0.00					0.00		

Template Step 4- Unmitigated Risk Assessment (cont.)

SHRP2 Risk Management Template

HELP

Step 04 - Unmitigated Risk Assessment

Conduct Risk Assessment | Calculate Mean Severity Values | Clear All | <=== BACK | HOME | FWD===>

Risk		Probability of Occurrence			Mean Cost Change (CY $M)					Mean Duration Change (months)					
Label	Risk Description	Adjectival	Numerical	Mean Value	Risk Type	Adjectival	Numerical	Mean Value	Affected Phase	Risk Type	Adjectival	Numerical	Mean Value	Affected Phase	Risk Type
PL-1	Project funding delayed or reduced.			0.00				0.00					0.00		
PL-2	Opposition to removing access to US-555 fro 12th St.	L		0.13	Threat	VL		0.10	Construction			0.00	0.00		

Risk Label	Risk Description	Risk Type	Mean Cost Impact (CY $M)	Mean Duration Impact (months)	Mean Disruption Impact (M-Hr)	Mean Change to Critical Path Schedule	Mean Severity (YOE $M)	Percent of Total Severity	Risk Ranking based on Mean Severity	Select Ris for Mitigation
SC-6	Provide new lighting throughout project.	Threat	0.58	0.00	0.00	0.00	0.62	8.21%	1	Yes
PR-1	Uncertainty in construction-cost inflation rate	Threat	0.58	0.00	0.00	0.00	0.62	8.21%	2	Yes
RR-1	Uncertainty in ROW inflation rate	Threat	0.58	0.00	0.00	0.00	0.60	8.03%	3	No
RR-3	Unwilling sellers	Threat	0.58	0.00	0.00	0.00	0.60	8.03%	4	Yes
RR-8	QDOT helps City pay for water and sewer-line relocation	Threat	0.58	0.00	0.00	0.00	0.60	8.03%	5	Yes
RR-2	Accelerating pace of development in interchange area	Threat	0.32	0.75	0.00	0.75	0.51	6.82%	6	Yes
CR-2	Additional Maintenance of Traffic required	Threat	0.19	0.07	0.03	0.07	0.51	6.74%	7	Yes
CR-4	Unable to construct interchange embankments as rapidly as assumed	Threat	0.11	0.75	0.00	0.75	0.39	5.21%	8	Yes
PD-13	Change in environmental documentation.	Threat	0.13	1.00	0.00	1.00	0.38	5.05%	9	No
PR-2	Uncertain Design/Build contracting market conditions at time of bid	Threat	0.30	0.25	0.00	0.25	0.38	5.00%	10	No
PD-11	Cannot use City sewer system for project runoff (or City charges for use).	Threat	0.32	0.19	0.00	0.19	0.37	4.99%	11	Yes
CR-3	Problems with planned accelerated bridge construction (ABC) technique	Threat	0.19	0.34	0.00	0.34	0.33	4.44%	12	Yes
PD-12	Structures impacted by Main Street realignment are eligible for Historic Register.	Threat	0.13	0.31	0.00	0.31	0.21	2.84%	13	No
PD-14	Delays completing environmental documentation.	Threat	0.00	0.75	0.00	0.75	0.18	2.45%	14	Yes
PD-4	Ground improvement required in interchange area.	Threat	0.13	0.08	0.00	0.08	0.17	2.25%	15	No
SC-3	Additional local improvements required.	Threat	0.11	0.19	0.00	0.19	0.16	2.11%	16	No

Template Step 5- Unmitigated Risk Register

RISK MANAGEMENT TEMPLATE STEPS

Step 01 - Project Structuring	Enter base project information (schedule, cost, etc.).
Step 02 - Risk Identification	Create list of potential risks.
Step 03 - Rating Scale	Enter values for scales used to assess risk severity.
Step 04 - Unmitigated Risk Assessment	Enter severity information for each risk to assess risk impact.
Step 05 - Unmitigated Risk Register	View unmitigated risks ranked by mean severity value.
Step 06 - Unmitigated Project Performance	View impact of unmitigated risks on project performance and schedule.
Step 07 - Unmitigated Risk Ranking Plots	View graphical ranking of unmitigated risks.
Step 08 - Risk Mitigation Strategies	Enter mitigation strategies for risks selected to be mitigated.
Step 09 - Mitigated Strategies Register	View summary of mitigation strategies selected for each mitigated risk.
Step 10 - Mitigated Risk Register	View mitigated risks ranked by mean severity value.
Step 11 - Mitigated Project Performance	View impact of mitigated risks on project performance and schedule.
Step 12 - Mitigated Risk Ranking Plots	View graphical ranking of mitigated risks.

Project Reset

NOTE: *This will clear all the data from the workbook. Once cleared, the data cannot be recovered!*

Summary Report

NOTE: *Executive or detailed summaries of the analysis can be created by clicking this*

2-29

Template Step 5- Unmitigated Risk Register (cont.)

SHRP2 Risk Management Template

HELP

Step 05 - Unmitigated Risk Register

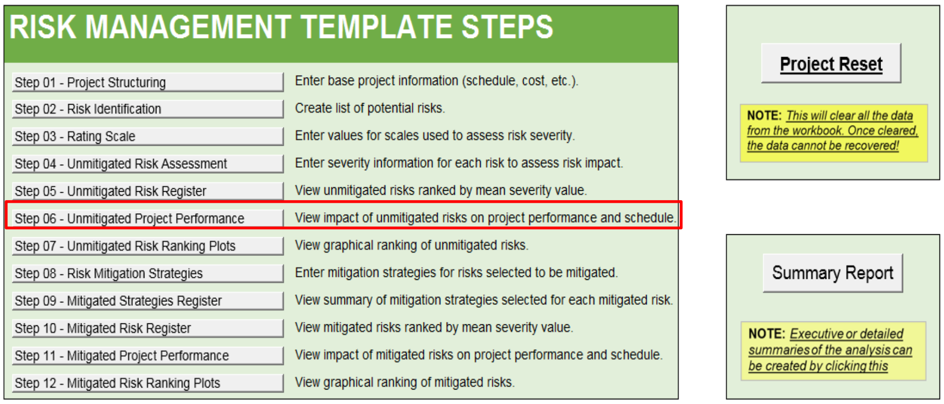
NOTE: Risks and opportunities are sorted by total severity, though the order should be identical whether using raw severity or percent of total severity

<=== BACK | HOME | FWD ===>

Risk Label	Risk Description	Risk Type	Mean Cost Impact (CY $M)	Mean Duration Impact (months)	Mean Disruption Impact (M-Hr)	Mean Change to Critical Path Schedule	Mean Severity (YOE $M)	Percent of Total Severity	Risk Ranking based on Mean Severity	Select Risk for Mitigation
SC-6	Provide new lighting throughout project.	Threat	0.58	0.00	0.00	0.00	0.62	8.21%	1	Yes
PR-1	Uncertainty in construction-cost inflation rate	Threat	0.58	0.00	0.00	0.00	0.62	8.21%	2	Yes
RR-1	Uncertainty in ROW inflation rate	Threat	0.58	0.00	0.00	0.00	0.60	8.03%	3	No
RR-3	Unwilling sellers	Threat	0.58	0.00	0.00	0.00	0.60	8.03%	4	Yes
RR-8	QDOT helps City pay for water and sewer-line relocation	Threat	0.58	0.00	0.00	0.00	0.60	8.03%	5	Yes
RR-2	Accelerating pace of development in interchange area	Threat	0.32	0.75	0.00	0.75	0.51	6.82%	6	Yes
CR-2	Additional Maintenance of Traffic required	Threat	0.19	0.07	0.03	0.07	0.51	6.74%	7	Yes
CR-4	Unable to construct interchange embankments as rapidly as assumed	Threat	0.11	0.75	0.00	0.75	0.39	5.21%	8	Yes
PD-13	Change in environmental documentation.	Threat	0.13	1.00	0.00	1.00	0.38	5.05%	9	No
PR-2	Uncertain Design/Build contracting market conditions at time of bid	Threat	0.30	0.25	0.00	0.25	0.38	5.00%	10	No
PD-11	Cannot use City sewer system for project runoff (or City charges for use).	Threat	0.32	0.19	0.00	0.19	0.37	4.99%	11	Yes
CR-3	Problems with planned accelerated bridge construction (ABC) technique	Threat	0.19	0.34	0.00	0.34	0.33	4.44%	12	Yes
PD-12	Structures impacted by Main Street realignment are eligible for Historic Register.	Threat	0.13	0.31	0.00	0.31	0.21	2.84%	13	No
PD-14	Delays completing environmental documentation.	Threat	0.00	0.75	0.00	0.75	0.18	2.45%	14	Yes
PD-4	Ground improvement required in interchange area.	Threat	0.13	0.08	0.00	0.08	0.17	2.25%	15	No
SC-3	Additional local improvements required.	Threat	0.11	0.19	0.00	0.19	0.16	2.11%	16	No

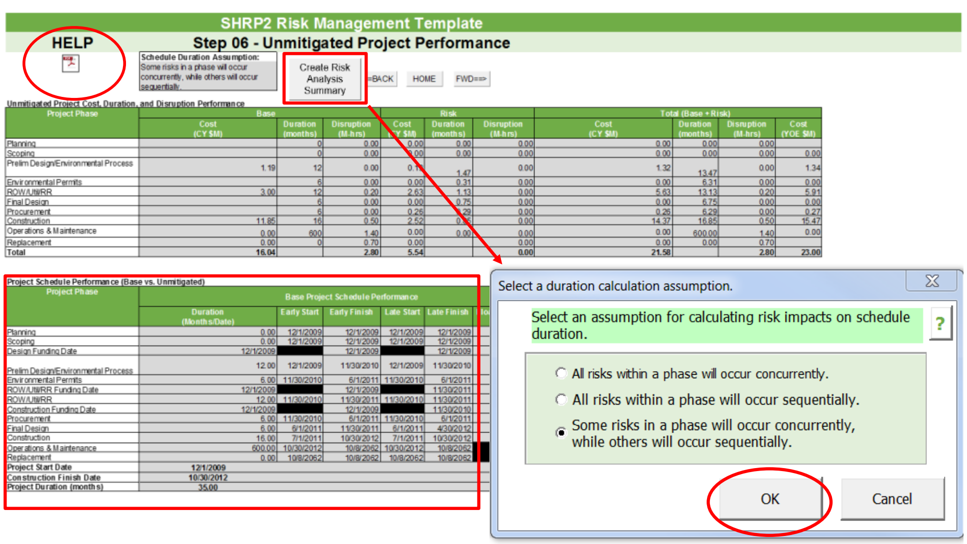
2-30

Template Step 6- Unmitigated Project Performance



2-31

Template Step 6- Unmitigated Project Performance (cont.)



2-32

Template Step 6- Unmitigated Project Performance (cont.)

SHRP2 Risk Management Template

Step 06 - Unmitigated Project Performance

HELP

Schedule Duration Assumption:
Some risks in a phase will occur concurrently, while others will occur sequentially.

Create Risk Analysis Summary | <==BACK | HOME | FWD==>

Unmitigated Project Cost, Duration, and Disruption Performance

Project Phase	Base			Risk			Total (Base + Risk)			
	Cost (CY $M)	Duration (months)	Disruption (M-hrs)	Cost (CY $M)	Duration (months)	Disruption (M-hrs)	Cost (CY $M)	Duration (months)	Disruption (M-hrs)	Cost (YOE $M)
Planning		0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Scoping		0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Prelim Design/Environmental Process	1.19	12	0.00	0.13	1.47	0.00	1.32	13.47	0.00	1.34
Environmental Permits		6	0.00	0.00	0.31	0.00	0.00	6.31	0.00	0.00
ROW/Util/RR	3.00	12	0.20	2.63	1.13	0.00	5.63	13.13	0.20	5.91
Final Design		6	0.00	0.00	0.75	0.00	0.00	6.75	0.00	0.00
Procurement		6	0.00	0.26	0.29	0.00	0.26	6.29	0.00	0.27
Construction	11.85	16	0.50	2.52	0.85	0.00	14.37	16.85	0.50	15.47
Operations & Maintenance	0.00	600	1.40	0.00	0.00	0.00	0.00	600.00	1.40	0.00
Replacement	0.00	0	0.70	0.00		0.00	0.00	0.00	0.70	
Total	**16.04**		**2.80**	**5.54**		**0.00**	**21.58**		**2.80**	**23.00**

Unmitigated Project Cost, Duration and Disruption Performance

2-33

Template Step 6- Unmitigated Project Performance (cont.)

SHRP2 Risk Management Template

Step 06 - Unmitigated Project Performance

HELP

Schedule Duration Assumption:
Some risks in a phase will occur concurrently, while others will occur sequentially.

Create Risk Analysis Summary | <==BACK | HOME | FWD==>

Project Schedule Performance (Base vs. Unmitigated)

Project Phase	Base Project Schedule Performance						Unmitigated Project Schedule Performance						Mean Severity YOE ($M)
	Duration (Months/Date)	Early Start	Early Finish	Late Start	Late Finish	Float (months)	Duration (Months / Date)	Early Start	Early Finish	Late Start	Late Finish	Float (months)	
Planning	0.00	12/1/2009	12/1/2009	12/1/2009	12/1/2009	0.00	0.00	12/1/2009	12/1/2009	12/1/2009	12/1/2009	0.00	0.01
Scoping	0.00	12/1/2009	12/1/2009	12/1/2009	12/1/2009	0.00	0.00	12/1/2009	12/1/2009	12/1/2009	12/1/2009	0.00	0.89
Design Funding Date	12/1/2009		12/1/2009		12/1/2009	0.00	12/1/2009		12/1/2009		12/1/2009	0.00	0.00
Prelim Design/Environmental Process	12.00	12/1/2009	11/30/2010	12/1/2009	11/30/2010	0.00	13.47	12/1/2009	1/14/2011	12/1/2009	1/14/2011	0.00	1.37
Environmental Permits	6.00	11/30/2010	6/1/2011	11/30/2010	6/1/2011	0.00	6.31	1/14/2011	7/25/2011	2/8/2011	8/19/2011	0.81	0.07
ROW/Util/RR Funding Date	12/1/2009		12/1/2009		11/30/2011	24.00	12/1/2009		12/1/2009		2/17/2012	26.59	0.00
ROW/Util/RR	12.00	11/30/2010	11/30/2011	11/30/2010	11/30/2011	0.00	13.13	1/14/2011	2/17/2012	1/14/2011	2/17/2012	0.00	2.48
Construction Funding Date	12/1/2009		12/1/2009		11/30/2010	12.00	12/1/2009		12/1/2009		2/8/2011	14.30	0.00
Procurement	6.00	11/30/2010	6/1/2011	11/30/2010	6/1/2011	0.00	6.29	1/14/2011	8/19/2011	2/8/2011	8/19/2011	0.00	1.01
Final Design	6.00	6/1/2011	11/30/2011	6/1/2011	4/30/2012	5.00	6.75	8/19/2011	3/11/2012	8/19/2011	8/13/2012	5.10	0.00
Construction	16.00	7/1/2011	10/30/2012	7/1/2011	10/30/2012	0.00	16.85	9/18/2011	2/11/2013	9/18/2011	2/11/2013	0.00	0.91
Operations & Maintenance	600.00	10/30/2012	10/8/2062	10/30/2012	10/8/2062		600.00	2/11/2013	1/20/2063	2/11/2013	1/20/2063		
Replacement	0.00	10/8/2062	10/8/2062	10/8/2062	10/8/2062		0.00	1/20/2063	1/20/2063	1/20/2063	1/20/2063		
Project Start Date	**12/1/2009**						**12/1/2009**					Total	6.74
Construction Finish Date	**10/30/2012**						**2/11/2013**						
Project Duration (months)	**35.00**						**38.45**						

Project Schedule Performance (Base vs. Unmitigated)
Note: Base performance results from Step 1

2-34

Template Step 7- Unmitigated Risk Ranking Plots

RISK MANAGEMENT TEMPLATE STEPS

Step 01 - Project Structuring	Enter base project information (schedule, cost, etc.).
Step 02 - Risk Identification	Create list of potential risks.
Step 03 - Rating Scale	Enter values for scales used to assess risk severity.
Step 04 - Unmitigated Risk Assessment	Enter severity information for each risk to assess risk impact.
Step 05 - Unmitigated Risk Register	View unmitigated risks ranked by mean severity value.
Step 06 - Unmitigated Project Performance	View impact of unmitigated risks on project performance and schedule.
Step 07 - Unmitigated Risk Ranking Plots	View graphical ranking of unmitigated risks.
Step 08 - Risk Mitigation Strategies	Enter mitigation strategies for risks selected to be mitigated.
Step 09 - Mitigated Strategies Register	View summary of mitigation strategies selected for each mitigated risk.
Step 10 - Mitigated Risk Register	View mitigated risks ranked by mean severity value.
Step 11 - Mitigated Project Performance	View impact of mitigated risks on project performance and schedule.
Step 12 - Mitigated Risk Ranking Plots	View graphical ranking of mitigated risks.

Project Reset

NOTE: *This will clear all the data from the workbook. Once cleared, the data cannot be recovered!*

Summary Report

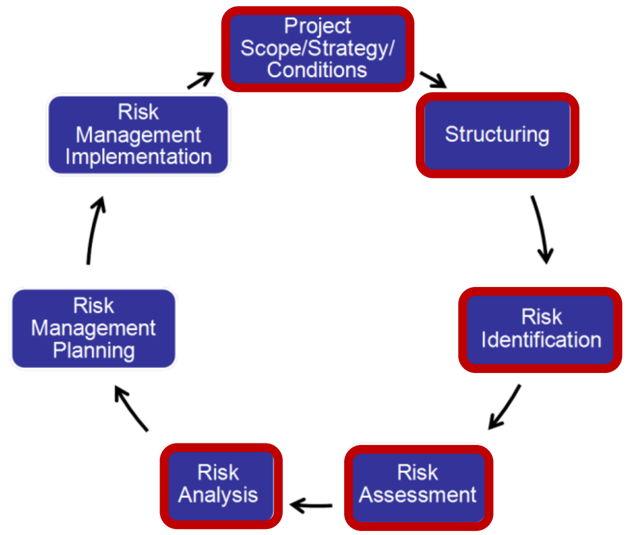
NOTE: *Executive or detailed summaries of the analysis can be created by clicking this*

2-35

Template Step 7- Unmitigated Risk Ranking Plots (cont.)

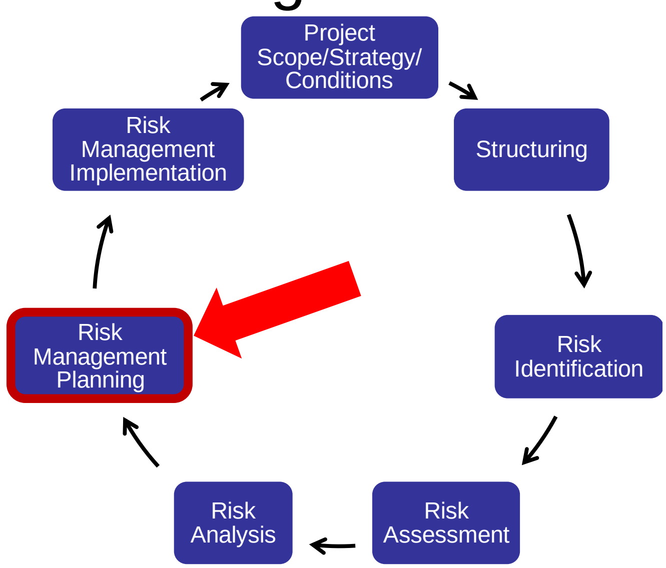
2-36

Questions on Structuring, Risk Identification or Risk Assessment?



2-37

Risk Management Process



2-38

Template Step 8- Risk Mitigation Strategies

RISK MANAGEMENT TEMPLATE STEPS

Step 01 - Project Structuring	Enter base project information (schedule, cost, etc.).
Step 02 - Risk Identification	Create list of potential risks.
Step 03 - Rating Scale	Enter values for scales used to assess risk severity.
Step 04 - Unmitigated Risk Assessment	Enter severity information for each risk to assess risk impact.
Step 05 - Unmitigated Risk Register	View unmitigated risks ranked by mean severity value.
Step 06 - Unmitigated Project Performance	View impact of unmitigated risks on project performance and schedule.
Step 07 - Unmitigated Risk Ranking Plots	View graphical ranking of unmitigated risks.
Step 08 - Risk Mitigation Strategies	Enter mitigation strategies for risks selected to be mitigated.
Step 09 - Mitigated Strategies Register	View summary of mitigation strategies selected for each mitigated risk.
Step 10 - Mitigated Risk Register	View mitigated risks ranked by mean severity value.
Step 11 - Mitigated Project Performance	View impact of mitigated risks on project performance and schedule.
Step 12 - Mitigated Risk Ranking Plots	View graphical ranking of mitigated risks.

Project Reset

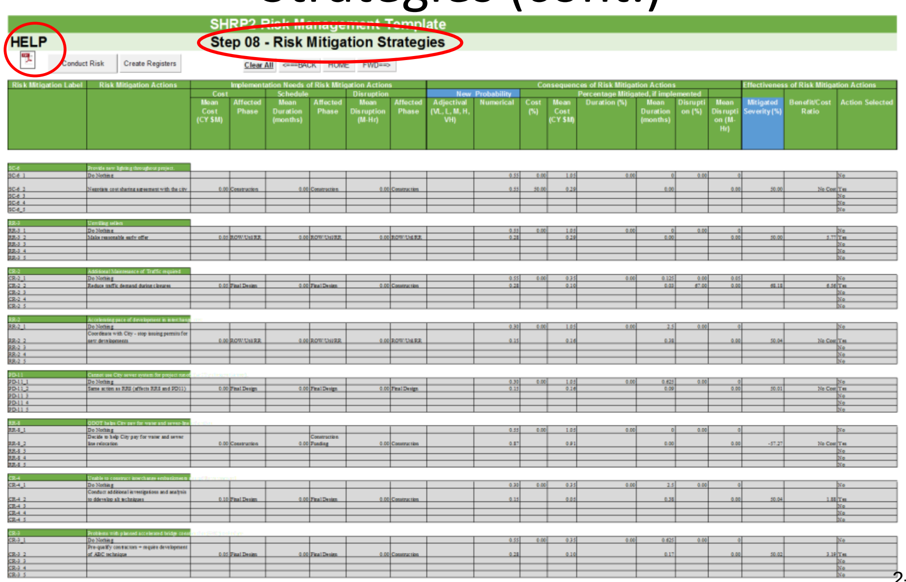
NOTE: *This will clear all the data from the workbook. Once cleared, the data cannot be recovered!*

Summary Report

NOTE: *Executive or detailed summaries of the analysis can be created by clicking this*

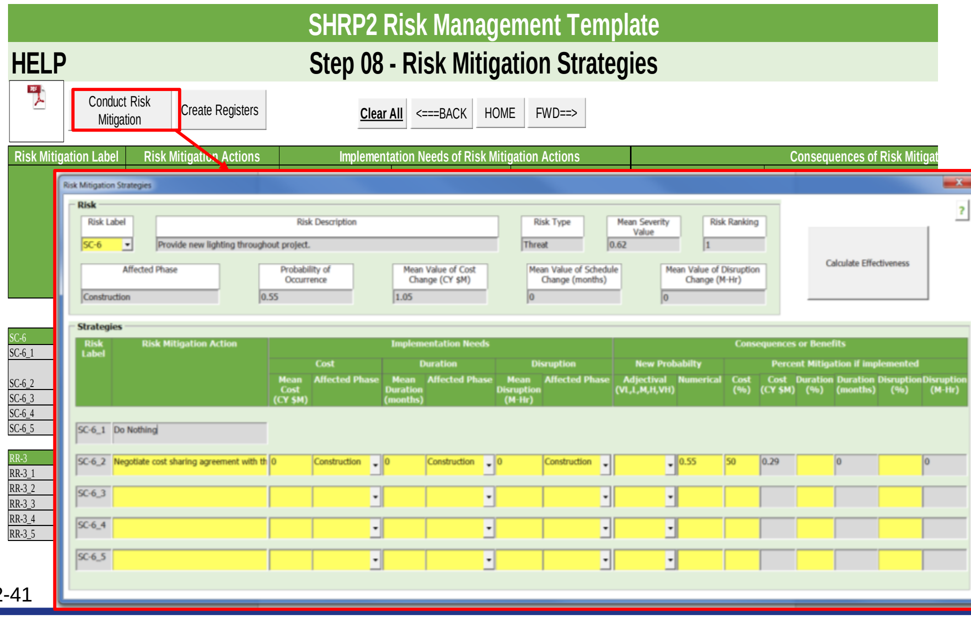
2-39

Template Step 8- Risk Mitigation Strategies (cont.)



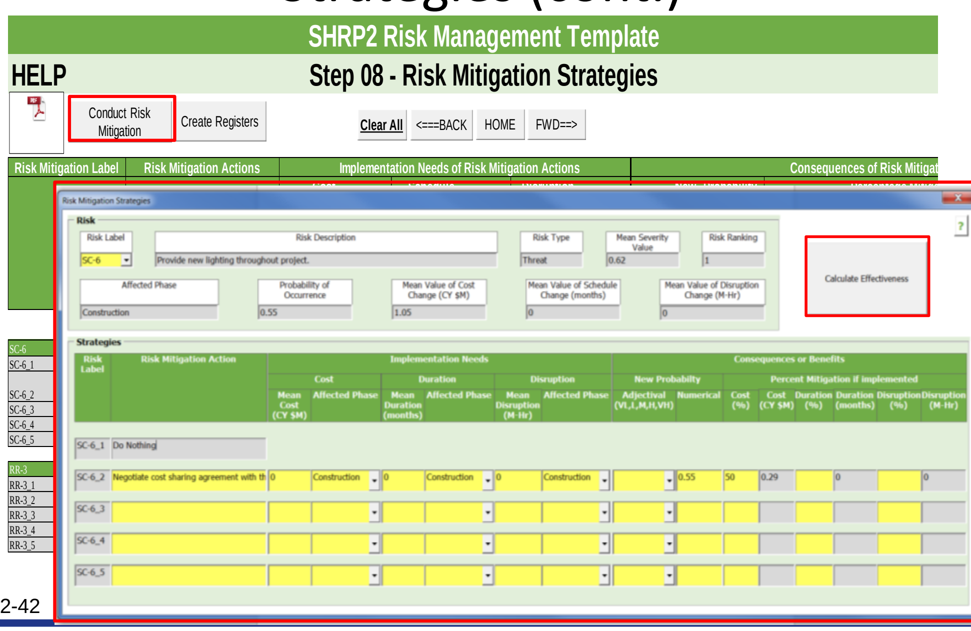
2-40

Template Step 8- Risk Mitigation Strategies (cont.)



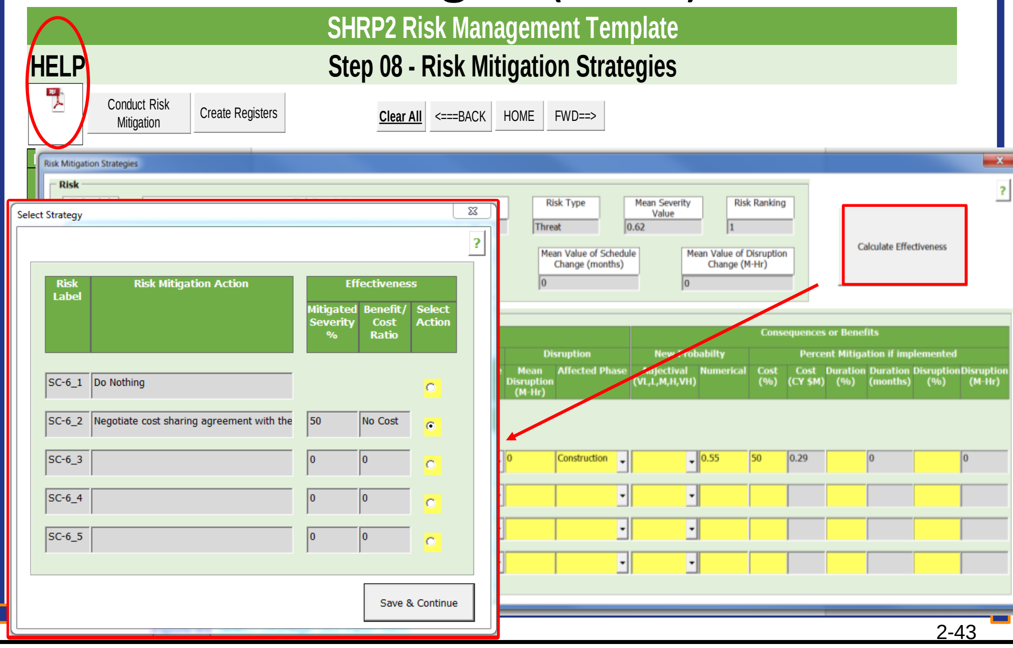
2-41

Template Step 8- Risk Mitigation Strategies (cont.)



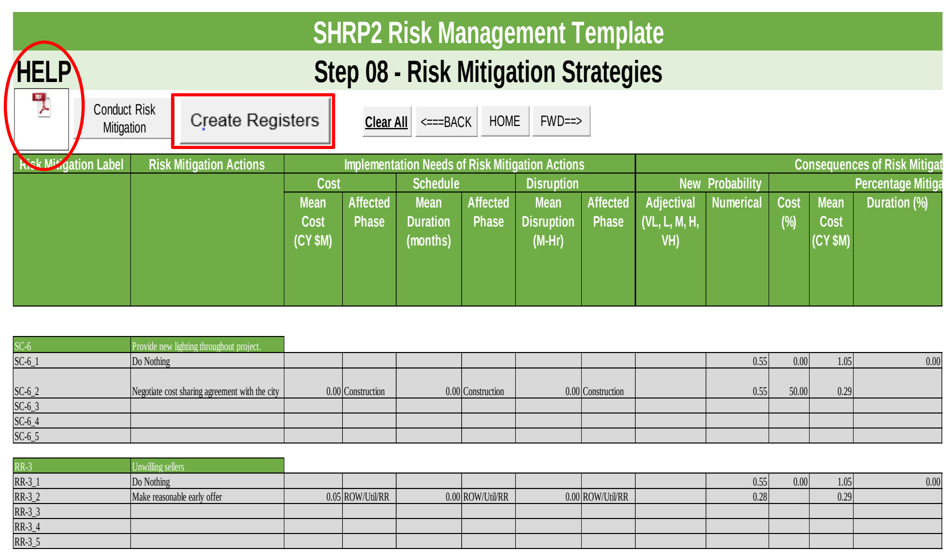
2-42

Template Step 8- Risk Mitigation Strategies (cont.)



2-43

Template Step 8- Risk Mitigation Strategies (cont.)



Risk Mitigation Label	Risk Mitigation Actions	Implementation Needs of Risk Mitigation Actions: Cost: Mean Cost (CY $M)	Cost: Affected Phase	Schedule: Mean Duration (months)	Schedule: Affected Phase	Disruption: Mean Disruption (M-Hr)	Disruption: Affected Phase	Consequences of Risk Mitigat: New Probability: Adjectival (VL, L, M, H, VH)	New Probability: Numerical	Percentage Mitiga: Cost (%)	Mean Cost (CY $M)	Duration (%)
SC-6	Provide new lighting throughout project.											
SC-6_1	Do Nothing								0.55	0.00	1.05	0.00
SC-6_2	Negotiate cost sharing agreement with the city	0.00	Construction	0.00	Construction	0.00	Construction		0.55	50.00	0.29	
SC-6_3												
SC-6_4												
SC-6_5												
RR-3	Unwilling sellers											
RR-3_1	Do Nothing								0.55	0.00	1.05	0.00
RR-3_2	Make reasonable early offer	0.05	ROW/Util/RR	0.00	ROW/Util/RR	0.00	ROW/Util/RR		0.28		0.29	
RR-3_3												
RR-3_4												
RR-3_5												

2-44

Template Step 9 – Mitigation Strategies Register

RISK MANAGEMENT TEMPLATE STEPS

Step 01 - Project Structuring	Enter base project information (schedule, cost, etc.).
Step 02 - Risk Identification	Create list of potential risks.
Step 03 - Rating Scale	Enter values for scales used to assess risk severity.
Step 04 - Unmitigated Risk Assessment	Enter severity information for each risk to assess risk impact.
Step 05 - Unmitigated Risk Register	View unmitigated risks ranked by mean severity value.
Step 06 - Unmitigated Project Performance	View impact of unmitigated risks on project performance and schedule.
Step 07 - Unmitigated Risk Ranking Plots	View graphical ranking of unmitigated risks.
Step 08 - Risk Mitigation Strategies	Enter mitigation strategies for risks selected to be mitigated.
Step 09 - Mitigation Strategies Register	View summary of mitigation strategies selected for each mitigated risk.
Step 10 - Mitigated Risk Register	View mitigated risks ranked by mean severity value.
Step 11 - Mitigated Project Performance	View impact of mitigated risks on project performance and schedule.
Step 12 - Mitigated Risk Ranking Plots	View graphical ranking of mitigated risks.

Project Reset

NOTE: *This will clear all the data from the workbook. Once cleared, the data cannot be recovered!*

Summary Report

NOTE: *Executive or detailed summaries of the analysis can be created by clicking this*

2-45

Template Step 9 – Mitigation Strategies Register (cont.)

SHRP2 Risk Management Template

HELP

Step 09 - Mitigation Strategies Register

NOTE: The order of the risks here is similar to the order of the risks selected for mitigation in Step 05- Unmitigated Risk Register

<===BACK | HOME | FWD===>

Risk Label	Risk Description	Risk Mitigation Label	Risk Mitigation Action Description	Implementation Effort: Mean Cost Change (YOE $M)	Implementation Effort: Mean Duration Change (YOE $M)	Implementation Effort: Mean Disruption Change (YOE $M)	Implementation Effort: Mean Change to Crit. Path (YOE $M)	Implementation Effort: Mean Severity (YOE $M)
SC-6	Provide new lighting throughout project.	SC-6 2	Negotiate cost sharing agreement with the city	0.00	0.00	0.00	0.00	0.00
RR-3	Unwilling sellers	RR-3 2	Make reasonable early offer	0.05	0.00	0.00	0.00	0.05
CR-2	Additional Maintenance of Traffic required	CR-2 2	Reduce traffic demand during closures	0.05	0.00	0.00	0.00	0.05
RR-2	Accelerating pace of development in interchange area	RR-2 2	Coordinate with City - stop issuing permits for new developments	0.00	0.00	0.00	0.00	0.00
PD-11	Cannot use City sewer system for project runoff (or City charges for use).	PD-11 2	Same action as RR8 (affects RR8 and PD11)	0.00	0.00	0.00	0.00	0.00
RR-8	ODOT helps City pay for water and sewer-line relocation	RR-8 2	Decide to help City pay for water and sewer line relocation	0.00	0.00	0.00	0.00	0.00
CR-4	Unable to construct interchange embankments as rapidly as assumed	CR-4 2	Conduct additional investigations and analysis to develop alt techniques	0.10	0.00	0.00	0.00	0.11
CR-3	Problems with planned accelerated bridge construction (ABC) technique	CR-3 2	Pre-qualify contractors + require development of ABC technique	0.05	0.00	0.00	0.00	0.05

Risk Label	Mitigated Risk Effort: Mean Cost Change (YOE $M)	Mitigated Risk Effort: Mean Duration Change (YOE $M)	Mitigated Risk Effort: Mean Disruption Change (YOE $M)	Mitigated Risk Effort: Mean Change to Crit. Path (YOE $M)	Mitigated Risk Effort: Mean Severity (YOE $M)	Effectiveness of Mitigation Actions: Mitigated Severity %	Effectiveness of Mitigation Actions: Benefit/Cost Ratio	Responsibility	Schedule /Milestone	Comments
SC-6	0.29	0.00	0.00	0.00	0.31	50.00	No Cost	Project Director	Midway thru prelim design	
RR-3	0.29	0.00	0.00	0.00	0.30	50.00	5.77	Project Engineer	Midway thru ROW/Util/RR	
CR-2	0.10	0.03	0.00	0.03	0.16	68.18	6.56	Project Engineer	Midway thru final design	
RR-2	0.16	0.38	0.00	0.37	0.26	50.04	No Cost	Project Engineer	Midway thru prelim design	
PD-11	0.16	0.09	0.00	0.09	0.19	50.01	No Cost	Project Engineer	Midway thru prelim design	
RR-8	0.91	0.00	0.00	0.00	0.95	-57.27	No Cost			
CR-4	0.05	0.38	0.00	0.38	0.20	50.04	1.88	Project Engineer	Midway thru final design	
CR-3	0.10	0.17	0.00	0.17	0.17	50.02	3.19	Project Engineer	Midway thru final design	

2-46

Template Step 10 – Mitigated Risk Register

RISK MANAGEMENT TEMPLATE STEPS

Step 01 - Project Structuring	Enter base project information (schedule, cost, etc.).
Step 02 - Risk Identification	Create list of potential risks.
Step 03 - Rating Scale	Enter values for scales used to assess risk severity.
Step 04 - Unmitigated Risk Assessment	Enter severity information for each risk to assess risk impact.
Step 05 - Unmitigated Risk Register	View unmitigated risks ranked by mean severity value.
Step 06 - Unmitigated Project Performance	View impact of unmitigated risks on project performance and schedule.
Step 07 - Unmitigated Risk Ranking Plots	View graphical ranking of unmitigated risks.
Step 08 - Risk Mitigation Strategies	Enter mitigation strategies for risks selected to be mitigated.
Step 09 - Mitigated Strategies Register	View summary of mitigation strategies selected for each mitigated risk.
Step 10 - Mitigated Risk Register	View mitigated risks ranked by mean severity value.
Step 11 - Mitigated Project Performance	View impact of mitigated risks on project performance and schedule.
Step 12 - Mitigated Risk Ranking Plots	View graphical ranking of mitigated risks.

Project Reset

NOTE: *This will clear all the data from the workbook. Once cleared, the data cannot be recovered!*

Summary Report

NOTE: *Executive or detailed summaries of the analysis can be created by clicking this*

2-47

Template Step 10 - Mitigated Risk Register (cont.)

SHRP2 Risk Management Template

HELP

Step 10 - Mitigated Risk Register

NOTE: Risks and opportunities are sorted by total severity, though the order should be identical whether using raw severity or percent of total severity

<===BACK HOME FWD===>

Risk Label	Risk Description	Risk Type	Mean Cost Impact (CY $M)	Mean Duration Impact (months)	Mean Disruption Impact (M-Hr)	Mean Change to Critical Path Schedule	Mean Severity (YOE $M)	Percent of Total Mean Severity	Risk Ranking based on Mean Severity	Retire Risk ?
RR-8	QDOT helps City pay for water and sewer-line relocation	Threat	0.91	0.00	0.00	0.00	0.95	0.16	1	No
PR-1	Uncertainty in construction-cost inflation rate	Threat	0.58	0.00	0.00	0.00	0.62	0.10	2	No
RR-1	Uncertainty in ROW inflation rate	Threat	0.58	0.00	0.00	0.00	0.60	0.10	3	No
PD-13	Change in environmental documentation.	Threat	0.13	1.00	0.00	1.00	0.38	0.06	4	No
PR-2	Uncertain Design/Build contracting market conditions at time of bid	Threat	0.30	0.25	0.00	0.25	0.38	0.06	5	No
SC-6	Provide new lighting throughout project.	Threat	0.29	0.00	0.00	0.00	0.31	0.05	6	No
RR-3	Unwilling sellers	Threat	0.29	0.00	0.00	0.00	0.30	0.05	7	No
RR-2	Accelerating pace of development in interchange area	Threat	0.16	0.38	0.00	0.37	0.26	0.04	8	No
PD-12	Structures impacted by Main Street realignment are eligible for Historic Register.	Threat	0.13	0.31	0.00	0.31	0.21	0.03	9	No

2-48

Template Step 11- Mitigated Project Performance

RISK MANAGEMENT TEMPLATE STEPS

Step 01 - Project Structuring	Enter base project information (schedule, cost, etc.).
Step 02 - Risk Identification	Create list of potential risks.
Step 03 - Rating Scale	Enter values for scales used to assess risk severity.
Step 04 - Unmitigated Risk Assessment	Enter severity information for each risk to assess risk impact.
Step 05 - Unmitigated Risk Register	View unmitigated risks ranked by mean severity value.
Step 06 - Unmitigated Project Performance	View impact of unmitigated risks on project performance and schedule.
Step 07 - Unmitigated Risk Ranking Plots	View graphical ranking of unmitigated risks.
Step 08 - Risk Mitigation Strategies	Enter mitigation strategies for risks selected to be mitigated.
Step 09 - Mitigated Strategies Register	View summary of mitigation strategies selected for each mitigated risk.
Step 10 - Mitigated Risk Register	View mitigated risks ranked by mean severity value.
Step 11 - Mitigated Project Performance	View impact of mitigated risks on project performance and schedule.
Step 12 - Mitigated Risk Ranking Plots	View graphical ranking of mitigated risks.

Project Reset

NOTE: *This will clear all the data from the workbook. Once cleared, the data cannot be recovered!*

Summary Report

NOTE: *Executive or detailed summaries of the analysis can be created by clicking this*

2-49

Template Step 11 - Mitigated Project Performance (cont.)

SHRP2 Risk Management Template

Step 11 - Mitigated Project Performance

HELP

Schedule Duration Assumption:
Some risks in a phase will occur concurrently, while others will occur sequentially.

Update Risk Analysis Summary

<==BACK HOME FWD==>

Mitigated Project Cost, Duration, and Disruption Performance

Project Phase	Base + Implementation			Residual Risk			Total (Base + Implementation + Residual Risk)			
	Cost (CY $M)	Duration (months)	Disruption (M-hrs)	Cost (CY $M)	Duration (months)	Disruption (M-hrs)	Cost (CY $M)	Duration (months)	Disruption (M-hrs)	Cost (YOE $M)
Planning	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Scoping	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Prelim Design/Environmental Process	1.19	12.00	0.00	0.13	1.47	0.00	1.32	13.47	0.00	1.34
Environmental Permits	0.00	6.00	0.00	0.00	0.31	0.00	0.00	6.31	0.00	0.00
ROW/Util/RR	3.05	12.00	0.20	2.35	0.70	0.00	5.40	12.70	0.20	5.67
Final Design	0.20	6.00	0.00	0.00	0.75	0.00	0.20	6.75	0.00	0.21
Procurement	0.00	6.00	0.00	0.22	0.29	0.00	0.22	6.29	0.00	0.23
Construction	11.85	16.00	0.50	1.88	0.38	-0.02	13.73	16.38	0.48	14.76
Operations & Maintenance	0.00	600.00	1.40	0.00	0.00	0.00	0.00	600.00	1.40	
Replacement	0.00	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.70	
Total (through Construction)	**16.29**		**0.70**	**4.58**		**-0.02**	**20.87**		**0.68**	**22.21**
Total (through Replacement)	**16.29**		**2.80**	**4.58**		**-0.02**	**20.87**		**2.78**	**22.21**

Mitigated Project Cost, Duration, and Disruption Performance

2-50

Template Step 11 - Mitigated Project Performance (cont.)

SHRP2 Risk Management Template

Step 11 - Mitigated Project Performance

HELP

Schedule Duration Assumption:
Some risks in a phase will occur concurrently, while others will occur sequentially.

Update Risk Analysis Summary

<==BACK HOME FWD==>

Project Schedule Performance (Unmitigated vs. Mitigated)

Project Phase	Unmitigated Project Schedule Performance (from step 6)						Mitigated Project Schedule Performance						Mean
	Duration (Months/ Date)	Early Start	Early Finish	Late Start	Late Finish	Float (months)	Duration (Months/ Date)	Early Start	Early Finish	Late Start	Late Finish	Float (months)	Severity YOE($M)
Planning	0.00	12/1/2009	12/1/2009	12/1/2009	12/1/2009	0.00	0.00	12/1/2009	12/1/2009	12/1/2009	12/1/2009	0.00	0.01
Scoping	0.00	12/1/2009	12/1/2009	12/1/2009	12/1/2009	0.00	0.00	12/1/2009	12/1/2009	12/1/2009	12/1/2009	0.00	0.58
Design Funding Date	12/1/2009		12/1/2009		12/1/2009	0.00	12/1/2009		12/1/2009		12/1/2009	0.00	0.00
Prelim Design/Environmental Process	13.47	12/1/2009	1/14/2011	12/1/2009	1/14/2011	0.00	13.47	12/1/2009	1/14/2011	12/1/2009	1/14/2011	0.00	1.18
Environmental Permits	6.31	1/14/2011	7/25/2011	2/8/2011	8/19/2011	0.81	6.31	1/14/2011	7/25/2011	1/26/2011	8/6/2011	0.39	0.07
ROW/Util/RR Funding Date	12/1/2009		12/1/2009		2/17/2012	26.59	12/1/2009		12/1/2009		2/4/2012	26.17	0.00
ROW/Util/RR	13.13	1/14/2011	2/17/2012	1/14/2011	2/17/2012	0.00	12.70	1/14/2011	2/4/2012	1/14/2011	2/4/2012	0.00	2.27
Construction Funding Date	12/1/2009		12/1/2009		2/8/2011	14.30	12/1/2009		12/1/2009		1/27/2011	13.88	0.00
Procurement	6.29	1/14/2011	8/19/2011	2/8/2011	8/19/2011	0.00	6.29	1/14/2011	8/6/2011	1/27/2011	8/6/2011	0.00	1.01
Final Design	6.75	8/19/2011	3/11/2012	8/19/2011	8/13/2012	5.10	6.75	8/6/2011	2/27/2012	8/6/2011	7/17/2012	4.63	0.00
Construction	16.85	9/18/2011	2/11/2013	9/18/2011	2/11/2013	0.00	16.38	9/5/2011	1/15/2013	9/5/2011	1/15/2013	0.00	0.20
Operations & Maintenance	600.00	2/11/2013	1/20/2063	2/11/2013	1/20/2063		600.00	1/15/2013	12/24/2062	1/15/2013	12/24/2062		
Replacement	0.00	1/20/2063	1/20/2063	1/20/2063	1/20/2063		0.00	12/24/2062	12/24/2062	12/24/2062	12/24/2062		
Project Start Date	**12/1/2009**						**12/1/2009**					Total	5.33
Construction Finish Date	**2/11/2013**						**1/15/2013**						
Project Duration (months)	**38.45**						**37.55**						

Project Schedule Performance (Unmitigated vs. Mitigated)

2-51

Template Step 12 – Mitigated Risk Ranking Plots

RISK MANAGEMENT TEMPLATE STEPS

Step 01 - Project Structuring	Enter base project information (schedule, cost, etc.).
Step 02 - Risk Identification	Create list of potential risks.
Step 03 - Rating Scale	Enter values for scales used to assess risk severity.
Step 04 - Unmitigated Risk Assessment	Enter severity information for each risk to assess risk impact.
Step 05 - Unmitigated Risk Register	View unmitigated risks ranked by mean severity value.
Step 06 - Unmitigated Project Performance	View impact of unmitigated risks on project performance and schedule.
Step 07 - Unmitigated Risk Ranking Plots	View graphical ranking of unmitigated risks.
Step 08 - Risk Mitigation Strategies	Enter mitigation strategies for risks selected to be mitigated.
Step 09 - Mitigated Strategies Register	View summary of mitigation strategies selected for each mitigated risk.
Step 10 - Mitigated Risk Register	View mitigated risks ranked by mean severity value.
Step 11 - Mitigated Project Performance	View impact of mitigated risks on project performance and schedule.
Step 12 - Mitigated Risk Ranking Plots	View graphical ranking of mitigated risks.

Project Reset

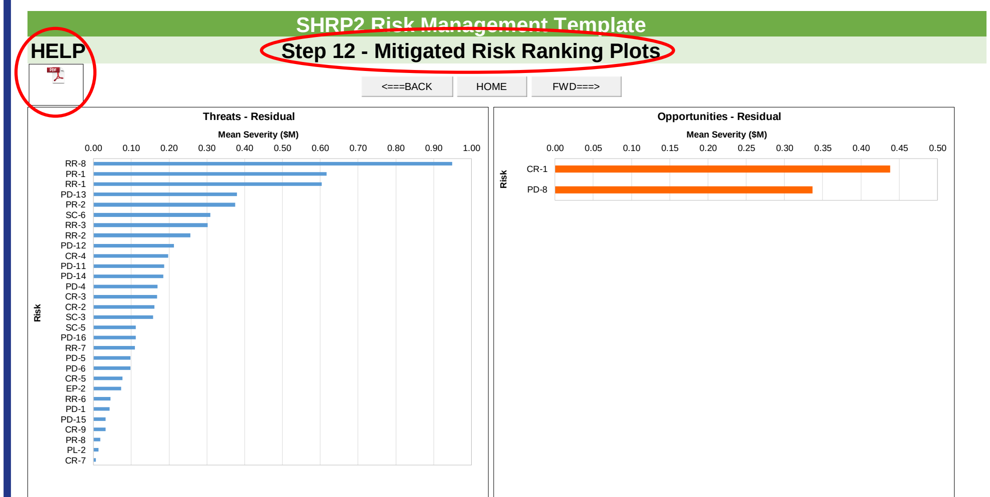
NOTE: *This will clear all the data from the workbook. Once cleared, the data cannot be recovered!*

Summary Report

NOTE: *Executive or detailed summaries of the analysis can be created by clicking this*

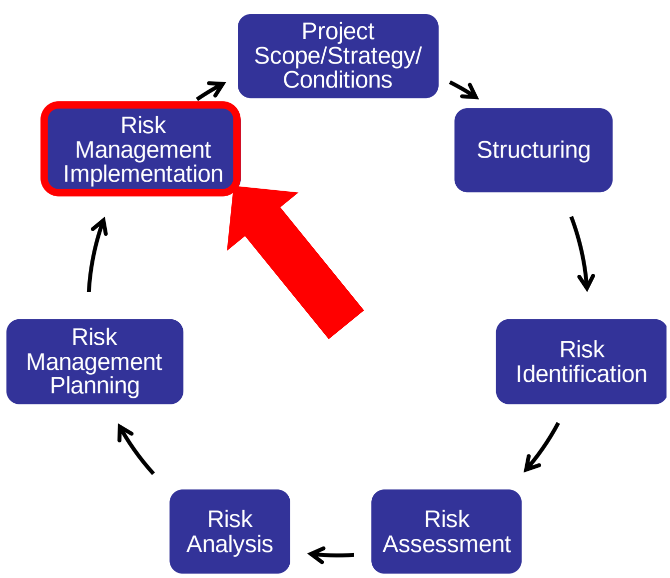
2-52

Template Step 12 - Mitigated Risk Ranking Plots (cont.)



2-53

Risk Management Process



2-54

Risk Management Implementation

RISK MANAGEMENT TEMPLATE STEPS

Step 01 - Project Structuring	Enter base project information (schedule, cost, etc.).
Step 02 - Risk Identification	Create list of potential risks.
Step 03 - Rating Scale	Enter values for scales used to assess risk severity.
Step 04 - Unmitigated Risk Assessment	Enter severity information for each risk to assess risk impact.
Step 05 - Unmitigated Risk Register	View unmitigated risks ranked by mean severity value.
Step 06 - Unmitigated Project Performance	View impact of unmitigated risks on project performance and schedule.
Step 07 - Unmitigated Risk Ranking Plots	View graphical ranking of unmitigated risks.
Step 08 - Risk Mitigation Strategies	Enter mitigation strategies for risks selected to be mitigated.
Step 09 - Mitigated Strategies Register	View summary of mitigation strategies selected for each mitigated risk.
Step 10 - Mitigated Risk Register	View mitigated risks ranked by mean severity value.
Step 11 - Mitigated Project Performance	View impact of mitigated risks on project performance and schedule.
Step 12 - Mitigated Risk Ranking Plots	View graphical ranking of mitigated risks.

Project Reset

NOTE: *This will clear all the data from the workbook. Once cleared, the data cannot be recovered!*

Summary Report

NOTE: *Executive or detailed summaries of the analysis can be created by clicking this*

2-55

Template – Summary Report

SHRP2 Risk Management Template

HELP **Summary Report**

UPDATE REPORT | PRINT REPORT | <==BACK | HOME | BACK TO SUMMARY | COPY

Note: Click on "Update Report" to ensure that this summary is populated with the latest data and charts

REPORT SUMMARY

TABLES

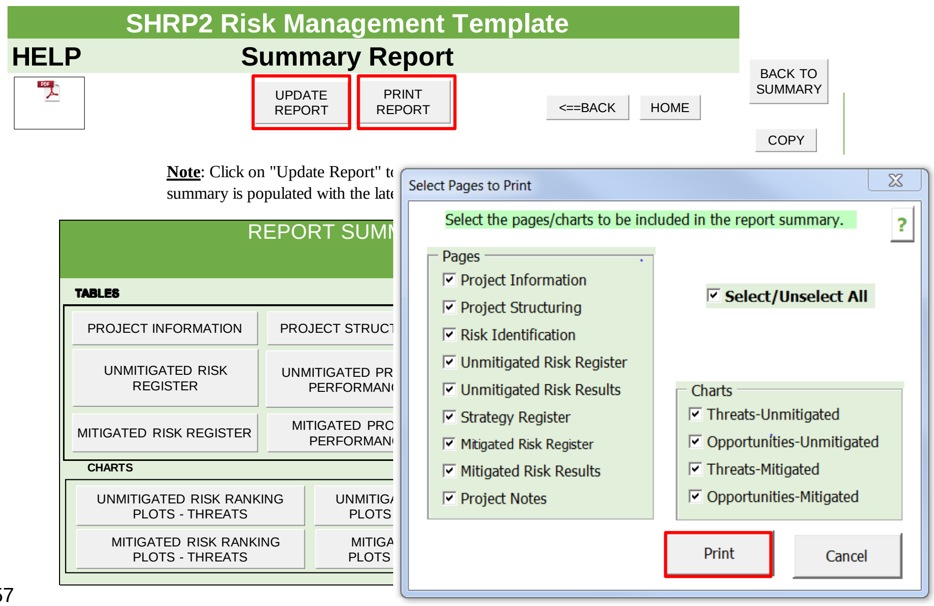
PROJECT INFORMATION	PROJECT STRUCTURING	RISK IDENTIFICATION
UNMITIGATED RISK REGISTER	UNMITIGATED PROJECT PERFORMANCE	MITIGATION STRATEGIES REGISTER
MITIGATED RISK REGISTER	MITIGATED PROJECT PERFORMANCE	PROJECT NOTES

CHARTS

UNMITIGATED RISK RANKING PLOTS - THREATS	UNMITIGATED RISK RANKING PLOTS - OPPORTUNITIES
MITIGATED RISK RANKING PLOTS - THREATS	MITIGATED RISK RANKING PLOTS - OPPORTUNITIES

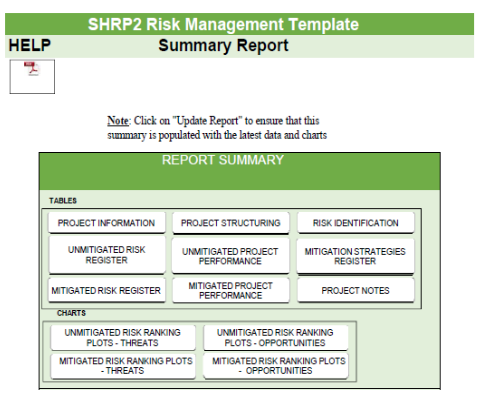
2-56

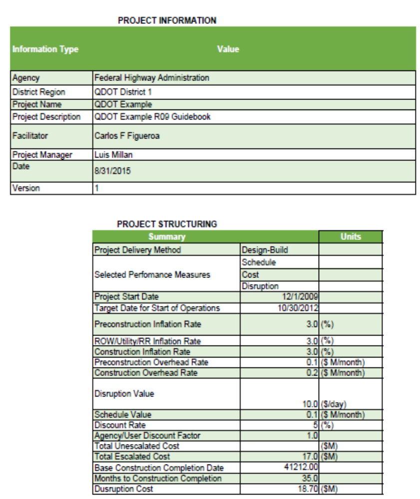
Template – Summary Report



2-57

Template – Summary Report (cont.)





PROJECT INFORMATION

Information Type	Value
Agency	Federal Highway Administration
District Region	QDOT District 1
Project Name	QDOT Example
Project Description	QDOT Example R09 Guidebook
Facilitator	Carlos F Figueroa
Project Manager	Luis Millan
Date	8/31/2015
Version	1

PROJECT STRUCTURING

Summary		Units
Project Delivery Method	Design-Build	
Selected Perfomance Measures	Schedule	
	Cost	
	Disruption	
Project Start Date	12/1/2009	
Target Date for Start of Operations	10/30/2012	
Preconstruction Inflation Rate	3.0	(%)
ROW/Utility/RR Inflation Rate	3.0	(%)
Construction Inflation Rate	3.0	(%)
Preconstruction Overhead Rate	0.1	($ M/month)
Construction Overhead Rate	0.2	($ M/month)
Disruption Value	10.0	($/day)
Schedule Value	0.1	($ M/month)
Discount Rate	5	(%)
Agency/User Discount Factor	1.0	
Total Unescalated Cost		($M)
Total Escalated Cost	17.0	($M)
Base Construction Completion Date	41212.00	
Months to Construction Completion	35.0	
Dusruption Cost	18.70	($M)

2-58

Template – Summary Report (cont.)

PROJECT STRUCTURING

Base Cost

Project Phase	Total Unesc Cost ($M)	Total Esc Cost ($M)	Duration (months)
Planning		0.0	0.0
Scoping		0.0	0.0
Prelim Design/Environmental Process	1.2	1.2	12.0
Environmental Permits		0.0	6.0
ROW/Util/RR	3.0	3.1	12.0
Final Design		0.0	6.0
Procurement		0.0	6.0
Construction	11.9	12.7	16.0
Operations & Maintenance	0.0	0.0	600.0
Replacement	0.0	0.0	0

Base Schedule

Project Phase	Months/Date	Early Start	Early Finish	Late Start	Late Finish	Float
Planning	0	12/1/2009	12/1/2009	12/1/2009	12/1/2009	0.0
Scoping	0	12/1/2009	12/1/2009	12/1/2009	12/1/2009	0.0
Design Funding Date	12/1/2009		12/1/2009		12/1/2009	0.0
Prelim Design/Environmental P	12	12/1/2009	11/30/2010	12/1/2009	11/30/2010	0.0
Environmental Permits	6	11/30/2010	6/1/2011	11/30/2010	6/1/2011	0.0
ROW/Util/RR Funding Date	12/1/2009		12/1/2009		11/30/2011	24.0
ROW/Util/RR	12	11/30/2010	11/30/2011	11/30/2010	11/30/2011	0.0
Procurement	6	11/30/2010	6/1/2011	11/30/2010	6/1/2011	0.0
Final Design	6	6/1/2011	11/30/2011	6/1/2011	4/30/2012	5.0
Construction	16	7/1/2011	10/30/2012	7/1/2011	10/30/2012	0.0
Operations & Maintenance	600	10/30/2012	10/8/2062	10/30/2012	10/8/2062	
Replacement	0	10/8/2062	10/8/2062	10/8/2062	10/8/2062	

SUMMARY OF RISK IDENTIFICATION

Project Phase	Number of Risks Identified in Each Phase
Planning	4
Scoping	7
Design Funding Date	0
Prelim Design/Environmental Process	16
Environmental Permits	2
ROW/Util/RR Funding Date	0
ROW/Util/RR	10
Construction Funding Date	0
Procurement	8
Final Design	0
Construction	12
Operations & Maintenance	0
Replacement	0
Total	59

2-59

Template – User Guide (cont.)

SHRP2 RISK MANAGEMENT TEMPLATE

Risk manangement and analysis software for highway construction projects

User Guide

Prepared by

Applied Research Associates, Inc.
100 Trade Centre Dr., Suite 200
Champaign, IL 61820

April 2016

2-60

Template – User Guide (cont.)

SHRP2 Risk Management Template | User Guide

Table of Contents

iii

2-61

Template – User Guide (cont.)

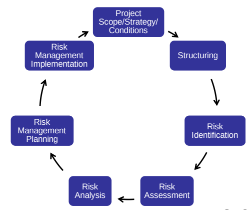
SHRP2 Risk Management Template | User Guide

iv

2-62

Summary- Introduction to R09 Risk Management Template

- The R09 Risk Management Template includes a Home screen, 12 steps and a summary report section
- The steps of the Template are interrelated with seven steps of the R09 risk management process



2-63

Questions?

goSHRP2@dot.gov

SHRP2 SOLUTIONS

Save lives. Save money. Save time.

2-64

List of all equations used in the SHRP2 R09 Risk Management Template

1. Schedule

Design-Bid-Build

Calculated Value	Formula
Planning-Early Start	$(Project\ Start\ Date)$
Planning-Early Finish	$(Planning - Early\ Start) + (Planning\ Duration)$
Planning-Late Start	$(Planning - Late\ Finish) - (Planning\ Duration)$
Planning-Late Finish	$(Scoping - Late\ Start)$
Scoping-Early Start	$(Planning - Early\ Finish)$
Scoping-Early Finish	$(Scoping - Early\ Start) + (Scoping\ Duration)$
Scoping-Late Start	$(Scoping - Late\ Finish) - (Scoping\ Duration)$
Scoping-Late Finish	$(Prelim\ Design/Env.Process - Late\ Start)$
Design Funding-Early Finish	$(Design\ Funding\ Date)$
Design Funding-Late Finish	$(Prelim\ Design/Env.Process - Late\ Start)$
Prelim Design/Env. Process-Early Start	$Latest\ of\ (Scoping - Early\ Finish, Design\ Funding - Early\ Finish)$
Prelim Design/Env. Process-Early Finish	$(Prelim\ Design/Env.Process - Early\ Start) + (Prelim\ Design/Env.Process\ Duration)$
Prelim Design/Env. Process-Late Start	$(Prelim\ Design/Env.Process - Late\ Finish) - (Prelim\ Design/Env.Process\ Duration)$
Prelim Design/Env. Process-Late Finish	$Earliest\ of\ (Environmental\ Permits - Late\ Start, ROW/Utilities/RR - Late\ Start, Final\ Design - Late\ Start)$
Environmental Permits-Early Start	$(Prelim\ Design/Env.Process - Early\ Finish)$
Environmental Permits-Early Finish	$(Environmental\ Permits - Early\ Start) + (Environmental\ Permits\ Duration)$
Environmental Permits-Late Start	$(Environmental\ Permits - Late\ Finish) - (Environmental\ Permits\ Duration)$
Environmental Permits-Late Finish	$(Procurement - Late\ Start)$
ROW/Utilities/RR Funding-Early Finish	$(ROW/Utilities/RR\ Funding\ Date)$
ROW/Utilities/RR Funding-Late Finish	$(ROW/Utilities/RR - Late\ Finish) - Lag\ E$
ROW/Utilities/RR-Early Start	$(Prelim\ Design/Env.Process - Early\ Finish)$
ROW/Utilities/RR-Early Finish	$Latest\ of\ (ROW/Utilities/RR - Early\ Start) + (ROW/Utilities/RR\ Duration), (ROW/Utilities/RR\ Funding - Early\ Finish) + Lag\ E$
ROW/Utilities/RR-Late Start	$(ROW/Utilities/RR - Late\ Finish) - (ROW/Utilities/RR\ Duration)$

ROW/Utilities/RR-Late Finish	$(Procurement - Late\ Start)$
Final Design-Early Start	$(Prelim\ Design/Env. Process - Early\ Finish)$
Final Design-Early Finish	$(Final\ Design - Early\ Start) + (Final\ Design\ Duration)$
Final Design-Late Start	$(Final\ Design - Late\ Finish) - (Final\ Design\ Duration)$
Final Design-Late Finish	$(Procurement - Late\ Start)$
Construction Funding-Early Finish	$(Construction\ Funding\ Date)$
Construction Funding-Late Finish	$(Procurement - Late\ Start)$
Procurement-Early Start	$Latest\ of\ (Environmental\ Permits - Early\ Finish, ROW/Utilities/RR - Early\ Finish, Final\ Design - Early\ Finish, Construction\ Funding - Early\ Finish)$
Procurement-Early Finish	$(Procurement - Early\ Start) + (Procurement\ Duration)$
Procurement-Late Start	$(Procurement - Late\ Finish) - (Procurement\ Duration)$
Procurement-Late Finish	$(Construction - Late\ Start)$
Construction-Early Start	$(Procurement - Early\ Finish)$
Construction-Early Finish	$(Construction - Early\ Start) + (Construction\ Duration)$
Construction-Late Start	$(Construction - Late\ Finish) - (Construction\ Duration)$
Construction-Late Finish	$(Construction - Early\ Finish)$

Design-Build Delivery

Calculated Value	Formula
Planning-Early Start	$(Project\ Start\ Date)$
Planning-Early Finish	$(Planning - Early\ Start) + (Planning\ Duration)$
Planning-Late Start	$(Planning - Late\ Finish) - (Planning\ Duration)$
Planning-Late Finish	$(Scoping - Late\ Start)$
Scoping-Early Start	$(Planning - Early\ Finish)$
Scoping-Early Finish	$(Scoping - Early\ Start) + (Scoping\ Duration)$
Scoping-Late Start	$(Scoping - Late\ Finish) - (Scoping\ Duration)$
Scoping-Late Finish	$(Prelim\ Design/Env. Process - Late\ Start)$
Design Funding-Early Finish	$(Design\ Funding\ Date)$
Design Funding-Late Finish	$(Prelim\ Design/Env. Process - Late\ Start)$
Prelim Design/Env. Process-Early Start	$Latest\ of\ (Scoping - Early\ Finish, Design\ Funding - Early\ Finish)$
Prelim Design/Env. Process-Early Finish	$(Prelim\ Design/Env. Process - Early\ Start) + (Prelim\ Design/Env. Process\ Duration)$
Prelim Design/Env. Process-Late Start	$(Prelim\ Design/Env. Process - Late\ Finish) - (Prelim\ Design/Env. Process\ Duration)$
Prelim Design/Env. Process-Late Finish	$Earliest\ of\ (Environmental\ Permits - Late\ Start, ROW/Utilities/RR - Late\ Start, Procurement - Late\ Start)$
Environmental Permits-Early Start	$(Prelim\ Design/Env. Process - Early\ Finish)$
Environmental Permits-Early Finish	$(Environmental\ Permits - Early\ Start) + (Environmental\ Permits\ Duration)$

Environmental Permits-Late Start	$(Environmental\ Permits - Late\ Finish) - (Environmental\ Permits\ Duration)$
Environmental Permits-Late Finish	$Earliest\ of\ [(Construction - Late\ Start), (Procurement - Late\ Finish) - Lag\ A + Lag\ B, (ROW/Utilities/RR - Late\ Finish) - Lag\ C + Lag\ D]$
ROW/Utilities/RR Funding-Early Finish	$(ROW/Utilities/RR\ Funding\ Date)$
ROW/Utilities/RR Funding-Late Finish	$(ROW/Utilities/RR - Late\ Finish) - Lag\ E$
ROW/Utilities/RR-Early Start	$(Prelim\ Design/Env.Process - Early\ Finish)$
ROW/Utilities/RR-Early Finish	$Latest\ of\ [(ROW/Utilities/RR - Early\ Start) + (ROW/Utilities/RR\ Duration), (ROW/Utilities/RR\ Funding - Early\ Finish) + Lag\ E, (Environmental\ Permits - Early\ Finish) - Lag\ D + Lag\ C]$
ROW/Utilities/RR-Late Start	$(ROW/Utilities/RR - Late\ Finish) - (ROW/Utilities/RR\ Duration)$
ROW/Utilities/RR-Late Finish	$Earliest\ of\ [(Construction - Late\ Start) + Lag\ F, (Construction - Late\ Finish) - Lag\ G, (Procurement - Late\ Finish) - Lag\ H + Lag\ I]$
Construction Funding-Early Finish	$(Construction\ Funding\ Date)$
Construction Funding-Late Finish	$(Procurement - Late\ Start)$
Procurement-Early Start	$Latest\ of\ [(Construction\ Funding - Early\ Finish), (Prelim\ Design/Env.Process - Early\ Finish)]$
Procurement-Early Finish	$Latest\ of\ [(Procurement - Early\ Start) + (Procurement\ Duration), (Environmental\ Permits - Early\ Finish) - Lag\ B + Lag\ A, (ROW/Utilities/RR - Early\ Finish) - Lag\ I + Lag\ H]$
Procurement-Late Start	$(Procurement - Late\ Finish) - (Procurement\ Duration)$
Procurement-Late Finish	$(Final\ Design - Late\ Start)$
Final Design-Early Start	$(Procurement - Early\ Finish)$
Final Design-Early Finish	$(Final\ Design - Early\ Start) + (Final\ Design\ Duration)$
Final Design-Late Start	$Earliest\ of\ [(Final\ Design - Late\ Finish) - (Final\ Design\ Duration), (Construction - Late\ Start) - Lag\ J]$
Final Design-Late Finish	$(Construction - Late\ Finish) - Lag\ H$
Construction-Early Start	$Latest\ of\ [(Environmental\ Permits - Early\ Finish), (Final\ Design - Early\ Start) + Lag\ J, (ROW/Utilities/RR - Early\ Finish) - Lag\ F]$
Construction-Early Finish	$Latest\ of\ [(Construction - Early\ Start) + (Construction\ Duration), (Final\ Design - Early\ Finish) + Lag\ K, (ROW/Utilities/RR - Early\ Finish) + Lag\ G$
Construction-Late Start	$(Construction - Late\ Finish) - (Construction\ Duration)$
Construction-Late Finish	$(Construction - Early\ Finish)$

2. Lag

Design Bid Build

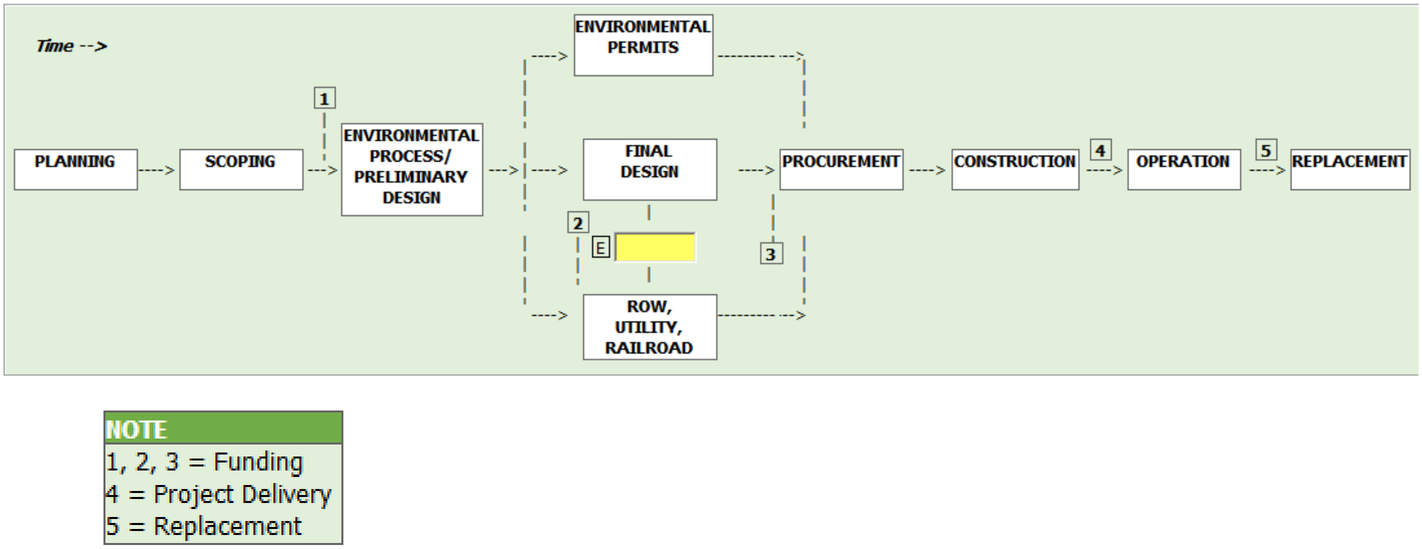


Figure 1: DBB Delivery Method

Lag: The minimum necessary amount of time between the finish (or start) of one activity prior to the finish (or start) of a succeeding activity in a network. It may be a positive or negative number. Lag times are defined by reference to the type or relationship being utilized (Start to Start, Start to Finish, Finish to Finish, or Finish to Start) and are defined from the perspective of a preceding activity's logic to one of its successors. Reference: *Delay Analysis in Construction Contracts* by P.J. Keane and A.F. Caletka.

Lag Description

Lag E - Time required to complete ROW/Utilities/RR after the completion of the ROW/Utilities/RR Funding date.

Design Build

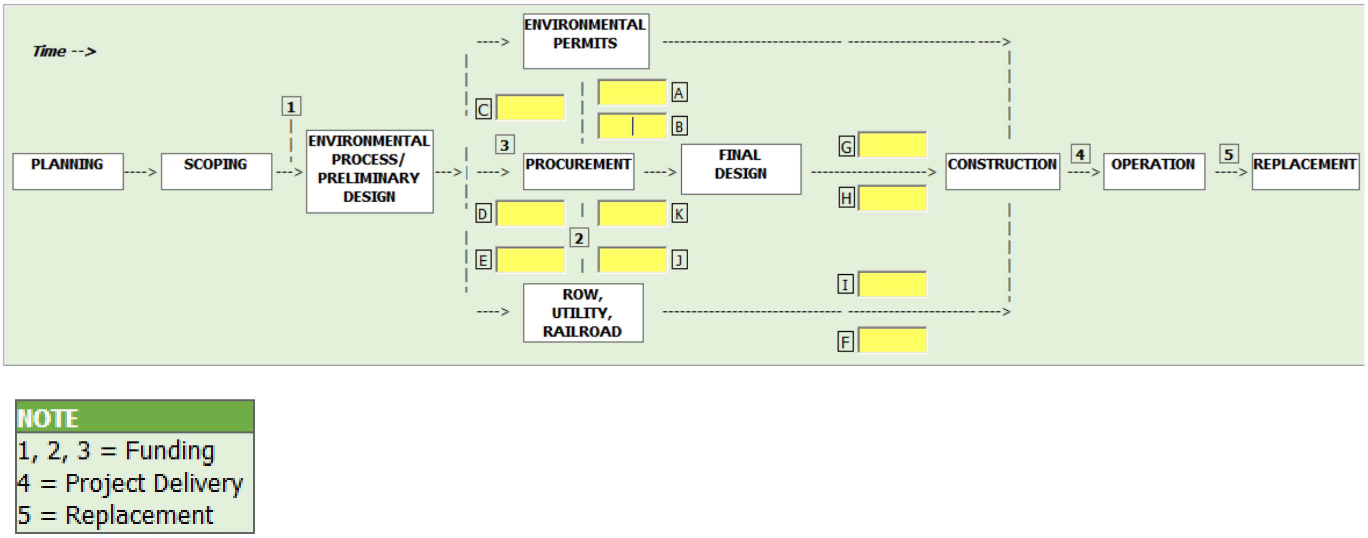


Figure 2: D-B Delivery Method

Lag Descriptions

Lag A – Lag remaining from the finish of Environmental permitting to Lag B.
Lag B – Time remaining after completion of Environmental Permitting to finish of Procurement.
Lag C – Lag remaining from finish of Environmental permits to Lag D.
Lag D – Time remaining after the completion of Environmental Permitting to the completion of ROW/Utilities/RR.
Lag E- Time remaining to finish ROW/Utilities/RR after the ROW/Utilities/RR funding date.
Lag F – Time elapsed from the completion of ROW/Utilities/RR to start of Construction.
Lag G – Time elapsed after the start of Final Design to start of Construction.
Lag H – Time remaining after the finish of Final Design to finish of Construction.
Lag I – Time remaining after finish of ROW/Utilities/RR to finish of Construction.
Lag J – Time remaining after finish of ROW/Utilities/RR to Lag K.
Lag K – Time remaining from finish of ROW/Utilities/RR to finish of Procurement.

3. Cost

Calculated Value	Formula
Base Cost + Overhead Cost (CY $M)	$(Project\ Phase\ Base\ Cost) + (Project\ Phase\ Duration) * (Overhead\ Rate\ (CY\ \$\ million/month))$
Base Cost + Overhead Cost (YOE $M)	$(Project\ Phase\ Base\ Cost + Overhead\ Rate(CY\ \$M)) * [(1 + Inflation\ Rate\ (\%/yr))\ \hat{}\ (time\ (yr))]$

Cost Variable Description

time – Amount of time between the project start date and the project phase early start date, plus one half of the project phase duration.[1]

1. Note: The definition and equation for *time* is based on the mean value method of the Risk Management Template. By using the mean costs and durations, all costs are calculated at the midpoint of the phase, thus adding one half of the phase duration to the beginning date of that phase.

4. Operation, Maintenance & Replacement

Calculated Value	Formula
Total Agency O&M Costs (YOE $M)	$\sum[(Agency\ O\&M\ Costs\ (CY\ \$M/yr)) * (Facility\ Performance\ Period)]$
Total Agency O&M Costs (CY $M)	$\sum[(Agency\ O\&M\ Costs\ (CY\ \$M/yr)) * (Net\ Present\ Value)]$
Net Present Value	$[1 - ((1 + Discount\ Rate) \wedge - (Facility\ Performance\ Period))] / (Discount\ Rate)$
Total O&M Disruption Value (YOE $M)	$\sum[(O\&M\ Disruption\ (M-Hr/yr)) * (Disruption\ Value\ (\$/hr)) * (Facility\ Performance\ Period)]$
Total O&M Disruption Value (CY $M)	$\sum[(O\&M\ Disruption\ (M-Hr/yr)) * (Disruption\ Value\ (\$/hr)) * (Net\ Present\ Value)]$
Total Agency Replacement Costs (YOE $M)	$\sum[(Agency\ Replacement\ Costs\ (CY\ \$M/event)) * (NumEvent)]$
Total Agency Replacement Costs (CY $M)	$\sum[(Agency\ Replacement\ Costs\ (CY\ \$M/event)) * (1 - (1 + (Discount\ Rate)) \wedge - (NumEvent)) / (Discount\ Rate)]$
Total Replacement Disruption Value (YOE $M)	$\sum[(Agency\ Replacement\ Disruption\ (M-Hr/event)) * (Disruption\ Value\ (\$/hr)) * (NumEvent)]$
Total Replacement Disruption Value (CY $M)	$\sum[(Agency\ Replacement\ Disruption\ (M\ Hr/event)) * (Disruption\ Value\ (\$/hr)) * (1 - (1 + (Discount\ Rate)) \wedge - (NumEvent)) / (Discount\ Rate)]$

OMR Variable Descriptions

Discount Rate – Percentage rate used to convert current year dollars to year-of-expenditure dollars.

Disruption Value – Number that represents the monetary value of one hour of disruption caused by the project.

NumEvent – Number of replacement events that will occur during the facility performance period for the specified asset. The number of events is defined as the Facility Performance Period / Asset Life Expectancy, rounded down to the nearest integer.

5. Disruption

Calculated Value	Formula
Disruption (M Veh Hrs)	$(Project\ Phase\ Disruption\ (M\ veh\ hrs/day)) * (No.of\ Days)$
Disruption Cost ($M)	$(Project\ Phase\ Disruption\ (M\ Veh\ Hrs)) * (Disruption\ Value\ (\$M/M\ Veh\ Hrs\ ))$

6. Calculating Mean Severity Values

Mean Severity Calculations are used for calculation of Mean Severity before and after Risk Mitigation.

1	Mean Cost Impact	Mean Cost Change * Probability
2	Mean Duration Impact	Mean Duration Change * Probability
3	Mean Disruption Impact	Mean Disruption Change * Probability
4	Mean Change to Critical Path	(Risk-Impacted Construction Early Finish Date) – (Base Construction Early Finish Date) Where, Risk-Impacted Construction Early Finish Date is new construction finish date after considering risk impact. The Risk-Impacted Construction Early Finish Date is calculated internally. This value takes into account the duration of the risk and compares it to the base schedule, lags, and floats. If the available float is exhausted, the template calculates the new Construction Early Finish Date accounting for the consequences of the risk (thus the Risk-Impacted Finish Date). The value is never displayed to the user and is only used for calculation of Mean Change to Critical Path.
5	Adjusted Mean Cost Change for Inflation	= 0, if Phase = "Operations & Maintenance" or Replacement $= Mean\ Cost\ Change * \left(1 + \frac{infrate}{100}\right)^{DNSD}$ where infrate is the inflation rate for the specific phases of project namely, preconstruction, ROW/RR/Utility and Construction $DNSD = \frac{\frac{BESD + BEED}{2} - PSD}{365.25}$ DNSD = Length of time from the start of the project to the midpoint of the phase duration (in years) BESD = Base Early Start Date BEED = Base Early End Date PSD = Project Start Date
6	Cost Impact of Schedule Delay	= 0, if Phase = "Operations & Maintenance" or Replacement = 0 , if infrate = 0 where infrate is the inflation rate for the specific phases of project namely, preconstruction, ROW/RR/Utility and

		Construction = SD – SND Where, SD = inflated cost of affected activity assuming schedule delay caused by risk $SD = BCSC * \left(1 + \frac{infrate}{100}\right)^{DSD}$ BCSC = Base cost of affected activity (+mean cost change if affected activity for cost and duration are the same). This value is equal to zero if the affected activities are the funding dates. DSD = Length of time from the Project Start Date to the midpoint of the phase duration (in years) + mean duration change $DSD\ (yrs) = \frac{\frac{BESD + BEED}{2} - PSD}{365.25} + \frac{Mean\ Duration\ Change}{12}$ SND = inflated cost of affected activity assuming no delay caused by risk $SND = BCSC * \left(1 + \frac{infrate}{100}\right)^{DSND}$ $DNSD = \frac{\frac{BESD + BEED}{2} - PSD}{365.25}$ DNSD = Length of time from the start of the project to the midpoint of the phase duration (in years) BESD = Base Early Start Date BEED = Base Early End Date PSD = Project Start Date
7	Overhead Cost Change due to inflation	= 0, if infrate = 0 , where infrate is the inflation rate for the specific phases of project namely, preconstruction, ROW/RR/Utility and Construction $= OH * MCC * \left(1 + \frac{infrate}{100}\right)^{DSD}$ Where, OH = unadjusted overhead cost/month MCC = Mean change to critical path DSD = Length of time from the Project Start Date to the midpoint of the phase duration (in years) + mean duration change (in months)

		$$DSD\ (yrs)\ = \frac{\frac{BESD + BEED}{2} - PSD}{365.25} + \frac{Mean\ Duration\ Change}{12}$$
8	Adjusted Base Cost of activities downstream of the affected phases for schedule delay	Based on the affected activity the base cost for the remaining phases are adjusted. $= \sum_{Phase\ following\ the\ affected\ phase}^{Final\ Phase}(SD - SND)$ Where, SD = inflated cost of affected activity assuming schedule delay caused by risk $$SD = BCSC * \left(1 + \frac{infrate}{100}\right)^{DSD}$$ BCSC = Base cost of affected activity (+mean cost change if affected activity for cost and duration are the same). This value is equal to zero if the affected activities are the funding dates. DSD = Length of time from the Project Start Date to the midpoint of the phase duration (in years) + mean duration change (in months) $$DSD\ (yrs) = \frac{\frac{BESD + BEED}{2} - PSD}{365.25} + \frac{Mean\ Duration\ Change}{12}$$ SND = inflated cost of affected activity assuming no delay caused by risk $$SND = BCSC * \left(1 + \frac{infrate}{100}\right)^{DSND}$$ $$DNSD = \frac{\frac{BESD + BEED}{2} - PSD}{365.25}$$ DNSD = Length of time from the start of the project to the midpoint of the phase duration (in years) BESD = Base Early Start Date BEED = Base Early End Date PSD = Project Start Date NOTE: 1. The infrate depends on the affected phase 2. BESD and BEED are the start and end date for that particular phase 3. This is calculated for every phase following the affected phase until all the phases are accounted for and the all the values are summed.
9	Adjusted Mean Disruption Change	= 0 , if disruption phase = [“Operations & Maintenance”, “Replacement”, “Design Funding”, "ROW/Utility/RR Funding”,

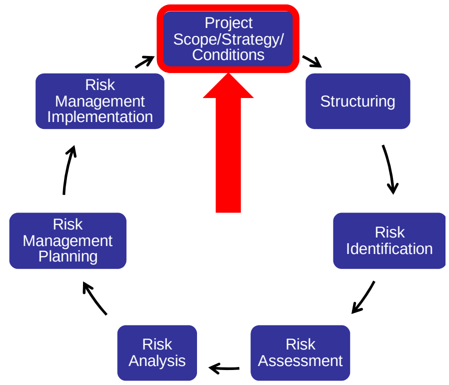
	The adjusted mean disruption change is used in all calculations of mean severity. This calculation is performed in steps 5 and 8 of the Template.	"Construction Funding"] $= MDC * DV * CDF$ Where, MDC = Mean Disruption Change, M-Hr DV = Disruption Value, $M/M-Hr CDF = Agency/User Cost Discount Factor
10	Total Activity Mean Severity (Column H on Steps 5 & 10 of Template)	= [4]* [Schedule Value] + [5] +[6] +[7] +[8] +[9]
11	Activity Percent of Total Severity (Steps 5 & 10 of Template)	$= Total\ Activity\ Mean\ Severity\ /\sum(Activity\ Mean\ Severity) \times 100$
12	Risk <u>Cost</u> per Phase (Step 6 of Template)	This calculation sums the *[Probability of Occurrence] x [Mean Cost Change]* for a given "Affected Phase" (Column J) in Step 4 of Template. For the QDOT example, the summation for "Prelim Design/Environmental Process" comes solely from Risk PD-13 and is calculated as 0.125 x 1.05 = 0.13125 (rounded to 0.13 in Cell E11 in Step 6 of Template). Note that all delays during preconstruction phases are assigned to the Procurement phase. Cost for preconstruction delays are added as follows: PreConstDelayCost = PreConstDelay x Preconstruction OH Rate Where, PreConstDelay = ((ConstES – PlanES)- (ConstBES - PlanBES)) / 30.4 ConstES = Construction Early Start after Risk, in days ConstBES = Base Construction Early Start, in days PlanES = Planning Early Start after Risk, in days PlanBES = Base Planning Early Start, in days Preconstruction OH Rate is found in Step 1 of Template, Cell J60. 30.4 = conversion factor from days to months Delays in construction are added to the Construction phase. Cost for construction delays are added as follows: ConstDelayCost = ConstDelay x Construction OH Rate Where, ConstDelay = ((ConstEF - ConstES) - (ConstBEF - ConstBES)) / 30.4 ConstEF = Construction Early Finish after Risk, in days ConstES = Construction Early Start after Risk, in days ConstBEF = Base Construction Early Finish, in days ConstBES = Base Construction Early Start, in days Construction OH Rate is found in Step 1, Cell J61.

		30.4 = conversion factor from days to months
13	Risk Duration per phase (Step 6 of Template)	This calculation is handled differently based on the analysis mode choice of the user. If the user selects to have the risks occur sequentially (Step 6 of Template), the template sums the *[Probability of Occurrence] x [Mean Duration Change]* for a given "Affected Phase" (Column O) in Step 4 of Template. For the QDOT example, the summation for "ROW/Util/RR" comes from Risks PD-1, PD-11, PD-12, RR-2, and RR-6. The calculated value is (0.025 x 2.50) + (0.30 x 0.625) + (0.125 x 2.50) + (0.30 x 2.50) + (0.30 x 0.625) = 1.50. If the user selects to have the risks occur concurrently, the template selects the maximum *Mean Duration Change Impact*, i.e. *[Probability of Occurrence] x [Mean Duration Change]* for a given "Affected Phase" (Column O) in Step 4 of Template. Again using "ROW/Util/RR" in the QDOT example, the maximum value is among PD-1, PD-11, PD-12, RR-2 and RR-6 is 0.75. If the user selects to have some risk occur sequentially and some risk occur concurrently, the template averages the results of the two above scenarios. For the case of "ROW/Util/RR", that calculation is (1.50 + 0.75)/2 = 1.125 (rounded to 1.13 in Step 6 of Template).
14	Risk Disruption per Phase (Step 6 of Template)	This calculation sums the *[Probability of Occurrence] x [Mean Disruption]* for a given "Affected Phase" (Column T) in Step 4 of Template. For the QDOT example, the summation for "Construction" comes from Risks CR-1 and CR-2 and is calculated as (0.25 x -0.10) + (0.55 x 0.05) = 0.0025 (rounded to 0.00 in Step 6 of Template).
15	Phase Mean Severity (YOE$M) (Steps 6 and 11 of Template)	This calculation is a summation of the calculated mean severities for a given project phase as seen in Step 5 o Template. For example, the summation of Phase Mean Severity for the "Scoping" phase is from risks SC-6, SC-3, and SC-5 and as calculated as follows: 0.62+0.16+0.11 = 0.89.
16	Mitigated Severity % (Step 9, Column O of Template)	$= \frac{(MSR - MSRM)}{MSR} * 100$ Where, MSR = Original Mean Severity of Risk without mitigation (Step 5, Column H of Template). MSRM = Adjusted Mean Severity of Risk after implementation of mitigation strategy (Step 9, Column N of Template).
17	Benefit/Cost Ratio	$= \frac{MSR - MSRM}{MSI}$

		Where, MSR = Original Mean severity of risk without mitigation (Step 5, Column H) MSRM = Adjusted Mean severity of risk after implementation of mitigation strategy (Step 9, Column N of Template). MSI = Mean severity of implementation of the mitigation strategy (Step 9, Column I of Template). Note if the MSI = 0, the Benefit/Cost Ratio will show "No Cost."
18	Residual Risk <u>Cost</u> per Phase (Step 11 of Template)	This calculation is performed in a manner identical to Equation 12. However, if a risk is mitigated, the Probability of Occurrence and the Mean Cost Change will come from Step 8, Columns J and L, respectively. All unmitigated risk values are from user input values in Step 4 of Template. The risks contributing to ROW/Util/RR residual risk cost are PD-1, PD-11, PD-12, RR-1, RR-2, RR-3, RR-7, and RR-8. Each of these risks contribute as follows: [Risk: *Probability of Occurrence x (1-Cost %) x Original Mean Cost of Risk*] • PD-1: 0.025 x (1–0.00) x 1.05 = 0.02624 • *PD-11: *0.15* x (1–0.00) x 1.05 = 0.1575 • PD-12: 0.125 x (1–0.00) x 1.05 = 0.13125 • RR-1: 0.55 x (1–0.00) x 1.05 = 0.5775 • *RR-2: *0.15* x (1–0.00) x 1.05 = 0.1575 • *RR-3: *0.275* x (1–0.00) x 1.05 = 0.28875 • RR-7: 0.30 x (1–0.00) x 0.35 = 0.105 • *RR-8: *0.865* x (1–0.00) x 1.05 = 0.90825 TOTAL RESIDUAL RISK COST ($M) = $2.352 (Unmitigated from Step 6 = $2.625M) * -- Mitigated risk. Values in *italics* are input by user in Step 8.
19	Residual Risk <u>Duration</u> per phase (Step 11 of Template)	This calculation is performed in a manner identical to Equation 13. However, if a risk is mitigated, the Probability of Occurrence and the Mean Duration Change will come from Step 8, Columns J and N, respectively. All unmitigated risk values are from user input values in Step 4 of Template. The risks contributing to Construction residual risk duration are PD-4, PD-5, PD-6, CR-1, CR-2, CR-3, CR-4, CR-5, and CR-7. Each of these risks contribute as follows: [Risk: *Probability of Occurrence x (1-Duration %) x Original Mean Duration of Risk*] • PD-4: 0.125 x (1–0.00) x 0.625 = 0.078125 • PD-5: 0.025 x (1–0.00) x 2.50 = 0.0625 • PD-6: 0.025 x (1–0.00) x 2.50 = 0.0625

		• CR-1: 0.25 x (1–0.00) x -2.00 = -0.50 • *CR-2: *0.275* x (1–0.00) x 0.125 = 0.034375 • *CR-3: *0.275* x (1–0.00) x 0.625 = 0.171875 • *CR-4: *0.15* x (1–0.00) x 2.50 = 0.375 • CR-5: 0.125 x (1–0.00) x 0.625 = 0.078125 • CR-7: 0.125 x (1–0.00) x 0.125 = 0.015625 TOTAL RESIDUAL RISK DURATION (months) = 0.378125 MAX RESIDUAL RISK DURATION (months) = 0.375 (CR-4) AVG OF TOTAL & MAX RESIDUAL DURATION = 0.3765625 * -- Mitigated risk. Values in *italics* are input by user in Step 8 of Template. • The residual risk duration show in Step 11, Column F will show the TOTAL RESIDUAL RISK DURATION is the user selects to have risks occur sequentially. • The value will show MAX RESIDUAL RISK DURATION is the user selected to have risks occur concurrently. • The AVG OF TOTAL & MAX RESIDUAL DURATION will show if the user selects to have some risk occur sequentially and some risks to occur concurrently.
20	Residual Risk <u>Disruption</u> per Phase (Step 11 of Template)	This calculation is performed in a manner identical to Equation 14. However, if a risk is mitigated, the Probability of Occurrence and the Mean Duration Change will come from Step 8, Columns J and P, respectively. All unmitigated risk values are from user input values in Step 4 of Template. The risks contributing to Construction residual risk disruption are CR-1 and CR-2. Each of these risks contribute as follows: [Risk: *Probability of Occurrence x (1-Disruption %) x Original Mean Disruption of Risk*] • CR-1: 0.25 x (1-0.00) x 0.10 = -0.025 • *CR-2: *0.275* x (1-*0.67*) x 0.05 = 0.0045375 TOTAL RESIDUAL RISK DISRUPTION (M-hr) = -0.0204625 * -- Mitigated risk. Values in *italics* are input by user in Step 8 of Template.

Module 3: Project Scope, Strategy, and Conditions



3-1

Project Scope, Strategy, and Conditions

- **Learning Outcomes**
- Purpose and Importance
- Project Description Form
- QDOT Case Study
- Summary

3-2

Learning Outcomes

- Define the project scope, strategy, and conditions in the context of risk management
- Describe the scope, strategy, and conditions of a hypothetical project (QDOT case study)

3-3

Project Scope, Strategy, and Conditions

- Learning Outcomes
- **Purpose and Importance**
- Project Description Form
- QDOT Case Study
- Summary

3-4

Project Scope, Strategy, and Conditions

- Understanding the project scope, delivery method, current conditions, and identifying assumptions are the key to begin an adequate risk management process.
- Predecessor for *Structuring*
- Foundation of risk management process

3-5

Project Scope, Strategy, and Conditions

- Learning Outcomes
- Purpose and Importance
- **Project Description Form**
- QDOT Case Study
- Summary

3-6

Project Description Form

Facilitates understanding and documentation of key project elements, such as:

- Planned scope and alternatives
- Status, delivery, and funding strategies
- Significant conditions affecting project (e.g. ROW, utilities, wetland impacts, etc.)
- Assumptions used in cost estimate and schedule
- Latest cost and schedule

3-7

Summary Base Project Description Form

Summary Project Description

Brief Project Description:
<insert>

Project Scope, Strategy/Status, and Key Conditions and Assumptions (identify):

- Detailed scope (including alternatives): <insert>
- Funding: <insert>
- Design:
  - Design level: <insert>
  - Structural: <insert>
  - Geotechnical: <insert>
  - Drainage: <insert>
  - Pavement: <insert>
  - Systems (including lighting and ITS)
  - Design deviations: <insert>
- Environmental:
  - Environmental documentation: <insert>
  - Wetlands: <insert>
  - Streams: <insert>
  - ESA: <insert>
  - Floodplain: <insert>
  - Stormwater: <insert>
  - Contaminated/hazardous waste: <insert>
  - Section 106: <insert>
  - 4(f): <insert>
  - Permitting (incl 404): <insert>
- Right of way and other agreements
  - Right-of-Way: <insert>
  - Utilities: <insert>
  - Railroad: <insert>
  - Other stakeholders: <insert>
- Procurement:
  - Delivery method: <insert>
  - Contract packaging: <insert>
  - Market (general and specialty): <insert>
- Construction:
  - Construction access/restrictions (including seasonal, events, shifts/hours): <insert>
  - Maintenance of traffic/business: <insert>
  - Construction phasing: <insert>
- Post-construction ("longevity"):
  - O&M: <insert>
  - Replacement: <insert>

Project Schedule (delivery, O&M, replacement – abstracted on next sheet):
<summarize major activities/milestones, including discussion of basis and bias/conservatism>

Project Cost Estimate (delivery, O&M, replacement – abstracted on next sheet):
<summarize major elements and costs, including discussion of basis and bias/conservatism, escalation, NPV for long term, disruption cost, and schedule and longevity value>

Project Disruption Estimate (delivery, O&M, replacement – abstracted on next sheet):
<summarize major elements and disruption, including discussion of basis and bias/conservatism>

Project Tradeoffs (disruption, schedule, longevity):
<summarize policy values for combining performance measures>

Project Performance Analysis:
<summarize project schedule, cost (including inflation), disruption, longevity, and combined performance>

Project Schematics (Scope and Flowchart, customized or simplified – see next sheet):
<insert>

3-8

Project Scope, Strategy, and Conditions

- Learning Outcomes
- Purpose and importance
- R09 Project Description Form
- **QDOT Case Study**
- Summary

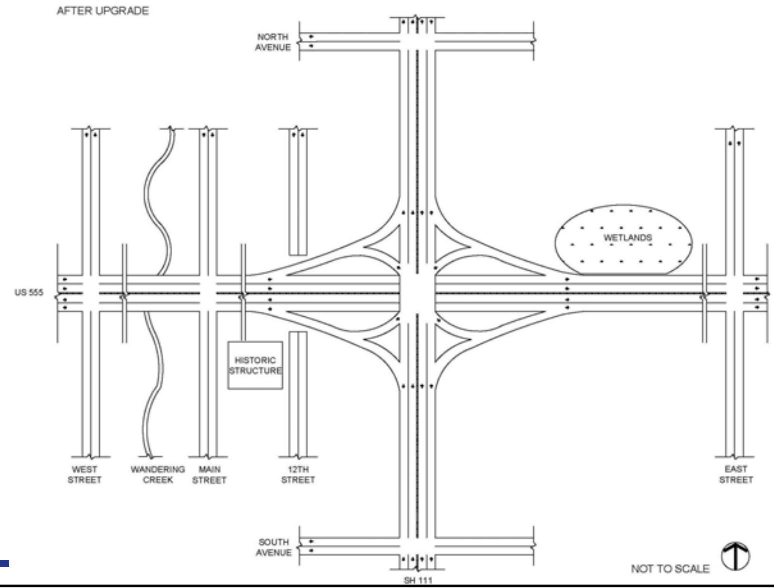
3-9

QDOT Case Study

1. Individually read Attachment A located at the end of Module 3: QDOT US-555/SH-111 Project Description form.
2. Identify key project elements including scope, strategy, conditions, and assumptions, and write them down.
3. Be prepared to discuss your observations.

3-10

QDOT Project Schematic



-11

QDOT Case Study Summary

Scope: QDOT will reconstruct/expand two intersecting highways

- **Scope alternatives**:
  - Rebuild existing alignment or split/shift alignment
  - Detour or realignment or full temporary closure (staging)
- **Strategy:**
  - Design-build with performance-based specifications
  - Minimize future repair cycles/maintenance requirements (maximize longevity)

3-12

QDOT Case Study Summary (cont.)

QDOT US-555/SH-111 Project Conditions

- Only viable E-W and N-S routes for commercial traffic (low disruption necessary
- Accelerated bridge construction
- NEPA: EA (assuming no significant ROW, wetland and historic impacts
- Section 106: Potential historical buildings
- Permits: USCOE 404 individual permit
- UTL: City water, sewer, electric, fiber optic, natural gas, telecommunications
- Railroad : No conflicts
- Replacement period: 50 yrs.

QDOT Case Study Summary (cont.)

QDOT US-555/SH-111 Project Assumptions

- 11-ft lanes and no shoulders on US-555 & SH-111:
  Assuming approval of FHWA design exception
- 10 to 15 ft ROW impact on wetlands:
  Assuming US-555 widening to north & roadway embankments sitting on retaining walls
- SH111: Concrete pavement:
  Assumed for longevity; however, QDOT open for contractor innovations

3-14

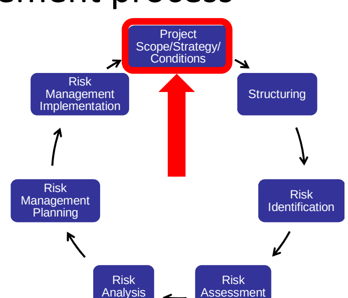
Project Scope, Strategy, and Conditions

- Learning Outcomes
- Purpose and Importance
- R09 Project Description Form
- QDOT Case Study
- **Summary**

3-15

Summary

- First step of risk management process
- Critical in ensuring an accurate understanding of project scope, conditions, assumptions, and impacts to facilitate risk management process
- Project description form facilitates a comprehensive understanding of the project



3-16

Questions?

goSHRP2@dot.gov

SHRP2 SOLUTIONS

Save lives. Save money. Save time.

3-17

E.3.1 Summary Project Description Form

Brief Project Description:

<Provide a brief (1 paragraph) summary of the project and illustrate it with a key schematic(s) to include:

- Existing system / reason for project;
- Objectives (functional and performance, including whether disruption through construction and/or post-construction longevity as well as schedule and cost through construction will be evaluated);
- Scope (incl any alternatives, project limits, capacity, etc.);
- Strategy (environmental process, project delivery method, contract packaging, phasing, access, etc.);
- Current status (e.g., design level, environmental process, funding, anticipated procurement, etc.); and
- Current conditions (environment, traffic, stakeholders, etc.).>

Project Scope, Strategy/Status, and Key Conditions and Assumptions (identify):

- Detailed scope (including any alternatives): <list comprehensive and non-duplicative set of major scope components (roadway segments and intersections/interchanges, including project limits, type/size/location, new/rehab/replacement, etc., with further details provided below under design)
- Funding: <describe current funding (amount, source, year) and, if needed, plans for remaining/additional funding (amount, source, year)>
- Design:
    - Design level: <current design level in %>
    - Structural: <list structures (location, type, size, new/rehab/replace)>
    - Geotechnical: <list structure foundations, slopes/cut/fill sections, retaining walls (location, type, size), fill base treatment>
    - Drainage: <describe drainage system (collection, storage, treatment, discharge)>
    - Pavement: <describe pavement system (concrete/asphalt/combination, new/replace/rehab/leave)>
    - Systems (including lighting and ITS): <describe any significant additional transportation features (lighting, ITS, etc.)>
    - Design deviations (exceptions or variances): <list significant design deviations that will require approval (e.g., shoulder widths, speed, etc.)>
- Environmental:
    - Environmental documentation: <describe the proposed environmental process (e.g., EA or EIS), and plans/status>
    - Wetlands: <identify any potentially affected wetlands, project's impacts and planned mitigation>
    - Streams: <identify any potentially affected stream, project's impacts and planned mitigation>
    - Section 7 of Endangered Species Act (ESA): <identify any potentially affected protected species (vegetation and animal), project's impacts and planned mitigation>
    - Floodplain: <identify any potentially affected floodplains, project's impacts and planned mitigation>
    - Stormwater: <describe anything not covered above under drainage design>
    - Contaminated/hazardous waste: <identify any potential contamination/hazardous waste, affect on project and planned mitigation>
    - Section 106: <identify any potential historic and/or archaeological features, project's impacts and planned mitigation>
    - 4(f): <identify any potential recreational features, project's impacts and planned mitigation>
    - Permitting (incl. 404): <list major project permits required, and plans/status for them>
    - Noise Abatement for Highway and Construction noise: <identify any potential increase in highway and construction noise, project's impacts and planned mitigation (e.g. noise walls, additional vegetation)>
    - Environmental Justice:< identify any potential environmental justice issues such as displacing or segregating minority or low-income communities, project's impacts and planned mitigation>
- Right of way and other agreements
    - Right-of-Way: <list properties/easements required for project, and plans/status for them>
    - Utilities: <list utilities that might be affected by project, and plans/status for them>
    - Railroad: <describe any railroad/transit interactions, and plans/status for them>
    - US Coast Guard: <describe any Coast Guard interactions, necessary permits, and plan/status for them>
    - Other stakeholders: <list other groups that might be affected by (or could affect) the project (e.g., environmental agency, permitting agencies, design approval, local jurisdictions, Native American tribes, public, as well as RoW, utilities, and railroad), and plans/status for them>
- Procurement:

- o Delivery method: <identify whether will use traditional design-bid-build, design-build, or other method, and agency roles>
  - o Contract packaging: <identify major contracts (one or multiple), including any agency third party contracts (e.g., construction engineering and inspection for construction management / CM) >
  - o Market (general and specialty): <describe current/future contracting market and commodities (e.g., steel, asphalt, concrete, etc.) for this type of work, considering likely competing projects>
- Construction:
  - o Construction access/restrictions (including seasonal, events, shifts/hours): <describe planned access to work areas, as well as staging areas, and any possible limitations (e.g., seasonal weather/ESA issues, specific known events, shifts/hours)>
  - o Maintenance of traffic/business: <describe plans for maintaining traffic/business (including detours, phasing, construction restrictions) and, *only if project "disruption through construction" is to be evaluated*, resulting nature of disruption>
  - o Construction phasing: <describe anticipated phasing of work, as well as general means and methods>
- Post-construction ("longevity"): *only if project "longevity" is to be evaluated*
  - o O&M: <describe anticipated O&M plans (i.e., scope and frequency) once construction is complete>
  - o Replacement: <describe anticipated replacement plans (i.e., when, scope, limitations, means/methods, etc.>

Project Schedule (for delivery and, *only if project "longevity" is to be evaluated,* **O&M and replacement):**

<Summarize major activities/milestones, their sequence and durations/overlaps/dates, including discussion of basis and bias/conservatism>

Project Cost Estimate (for delivery and, *only if project "longevity" is to be evaluated,* **O&M and replacement):**

<Summarize major elements and their costs (including quantities and unit costs/markups), including discussion of basis and bias/conservatism, escalation and their allocation to schedule activities>

Project "Disruption" Estimate (*only if project "disruption through construction" is to be evaluated,* **for delivery and,** *only if project "longevity" is to be evaluated,* **O&M and replacement):**

<Summarize major elements and their "disruption" (i.e., number of public affected and their average lost time), including discussion of basis and bias/conservatism>

Project Schematics (Scope and Flowchart):

<Illustrate project major scope elements and relevant conditions, and sequence of project major schedule activities>

ATTACHMENT A. PROJECT DESCRIPTION

QDOT is planning to reconstruct and expand segments of two existing (intersecting) highways, US 555 and SH 111, through a rapidly-developing suburban area (see Figure A-1). The existing highways are nearly 40 years old, have increasingly inadequate capacity, and are expensive to maintain. These facilities are the only viable east-west (US 555) and north-south (SH 111) routes for commercial traffic for several miles in either direction. Therefore, it is imperative that the necessary improvements be made quickly and with minimal disruption. QDOT would also like to minimize construction costs and future repair cycles and maintenance requirements, as well as eventual replacement issues. To help achieve these objectives, QDOT plans to encourage contractor innovation through the use of performance-based specifications and incentives, and to procure with an innovative project delivery method (i.e., design-build or D/B). It is expected that accelerated bridge construction techniques, minimally disruptive MOT, and innovative pavement design, among other rapid renewal elements, will be considered for this project.

- <u>Detailed scope (including alternatives)</u>:
  - **Upgrade** the existing unlimited-access, two-lane **US 555 into a limited-access, four-lane highway**. This includes reconstruction of the existing roadway section.
    - The limits of the upgrade are still not established, but the current assumption is from just west of West Street (1 mile west of SH 111) to just east of East Street (1 mile east of SH 111), including signalized intersections at each street.
    - US 555 will have four 11-foot lanes and no shoulders. A concrete median barrier will separate eastbound and westbound lanes. Concrete pavement is assumed for longevity; however, QDOT is open to innovative designs (e.g., composite pavement) from the contractor. QDOT currently assumes that FHWA will approve a design exception / deviation to build the facility with 11 ft lanes and no shoulders.
    - QDOT anticipates that US 555 will be widened to the north of the existing facility where possible because right-of-way is more readily available to the north. Even with no shoulders as assumed, and if the roadway embankment is supported by retaining walls as assumed, widening to the north will impact a 10- to 15-foot-wide strip of existing Class III wetlands along the east half of the upgrade. The cost estimate assumes this alternative.
  - **Upgrade** the existing unlimited-access, two-lane **SH 111 into a limited-access, four-lane highway**. This includes reconstruction of the existing roadway section.
    - The limits of improvement for SH 111 are from just north of North Avenue (1/2 mile north of interchange) to just south of South Avenue (1/2 mile south of interchange), including signalized intersections at each avenue.
    - SH 111 will also have four 11-foot lanes and no shoulders. A concrete median barrier will separate northbound and southbound lanes. Concrete pavement is assumed for longevity; however, QDOT is open to innovative designs from the contractor. QDOT currently assumes that FHWA will approve a design exception / deviation to build the facility with 11 ft lanes and no shoulders.
    - QDOT envisions that the contractor could propose one of two major alternatives to accomplish this upgrade while meeting its objectives for the project:
      - Rebuild on existing alignment: Build a detour for SH 111 around the existing facility, switch traffic onto the detour, then rapidly construct the approach embankments, abutment, and the new bridge (overpass) using accelerated bridge construction (ABC) techniques on the existing alignment, then switch traffic back onto the new facility on the original alignment and demolish the detour. This alternative is most likely and is assumed in QDOT's current cost estimate. Or,
      - Split / shift alignment: Instead of widening on the existing alignment, re-align (and perhaps separate northbound and southbound) around the existing alignment. This would allow rapid construction of approach embankments and bridge structures out of traffic and would keep traffic on the existing facility in the meantime. However, this approach would require more right-of-way (with greater business impacts) and is therefore not favored by QDOT. The City in particular is opposed to this alternative, as

are at least two known public groups. Note that this alternative likely would not require ABC techniques.

- **Convert** the at-grade **intersection of US 555 and SH 111 into a grade-separated interchange**.
    - QDOT anticipates that SH 111 will be carried over the top of US 555.
    - The type of interchange has not been finalized (the interchange design will be a function of the selected alignment for SH 111 as mentioned previously). QDOT plans to issue performance-based specifications to enable contractor innovation, but currently assumes (and estimates) the following consistent with building on the existing alignment:
        - Single-point urban interchange (SPUI). The existing right-of-way will accommodate this design, but this design might not provide the most operational benefit. Hence, other interchange designs might be feasible.
        - The structure type for the interchange has not been finalized, but the current assumption is a two-span, pre-cast concrete-girder structure. QDOT anticipates that the contractor will propose some sort of accelerated bridge construction (ABC) to complete the abutment and bridge construction more rapidly than with traditional methods.
        - The design currently assumes drilled-shaft foundations for the structural piers. However, potentially poor soil conditions might require ground improvement as well.
        - No on-site fill material is available for construction of the approach embankments, which are assumed to be retained fill to minimize ROW impacts.
- **Re-align the arterial (Main Street) intersection** to be perpendicular with US 555 (from its current significant skew). Re-alignment of Main Street will require new right-of-way near the at-grade and signalized intersection. In addition, realigning Main Street will impact several old structures. The baseline assumption is that these structures do not contain any asbestos and are not eligible for listing on the National Historic Register. The existing intersection of SH 555 with 12th Street will be removed (i.e., there will be no access to SH 555 from 12th Street).

- Funding: The project is fully funded at this time. Federal funding is involved.
- Design:
    - Design level: The project is in preliminary engineering (<10% design). If Design/Build (D/B) delivery method is chosen, QDOT would complete preliminary design (to 30% design) before turning the project over to the D/B contractor.
    - Structural: See above.
    - Geotechnical: See above.
    - Drainage: See below.
    - Pavement: See above.
    - Systems
        - Lighting: The design currently assumes new lighting only in the interchange area. However, there is some push for new lighting throughout the project (most of this area is currently lit, but some of the lighting would have to be moved during the widening).
        - ITS: ITS upgrades will be completed separately (in the future) as part of a corridor-wide upgrade.
    - Design deviations: See above.
- Environmental:
    - Environmental documentation: The team is conducting an Environmental Assessment (EA) based on the assumption of non-significant right-of-way, wetland, and potential historic impacts (note: because QDOT does not know what alignment/alternative the contractor will propose, it is assuming conservative impacts). Field studies are underway. The plan is to complete the draft EA prior to issuing the Request for Proposal (RFP) for D/B, and to have the EA finalized before issuing a Notice to Proceed (NTP) for D/B.
    - Wetlands: See above.
    - Streams: US 555 crosses Wandering Creek half a mile west of Main Street. The existing crossing is a small box culvert that is still serviceable and QDOT is not planning to replace it because QDOT believes it can be extended. However, the state fisheries agency has required QDOT to replace similar culverts with new larger culverts on recent projects.
    - ESA: No known issues. Currently, no listed fish species are believed to inhabit Wandering Creek this far upstream.

- Floodplain: None.
- Stormwater: The project assumes curb-and-gutter stormwater-runoff collection, with assumed conveyance to the City's existing combined stormwater/sanitary sewer system. The City has indicated that it might ask the project to pay for some upgrades to its system in exchange for the increased load, but this cost has not been included in the estimate. See also notes under "Utilities".
- Contaminated/hazardous waste: There could be some unanticipated contaminated soil or groundwater (likely hydrocarbons) in the interchange area. The estimate includes a small allowance for remediation of this material if exposed through foundation excavation. QDOT has not yet decided whether it will accept the risk of additional contamination, or allocate this risk to the contractor.
- Section 106: Potential historical buildings – see above.
- 4(f): No known issues.
- Permitting: A USACE 404 permit is required for the planned wetland impacts. The base assumes this will be an Individual permit, but if the design can be modified, wetland impacts could be less than anticipated and a Nationwide 404 permit might suffice. QDOT will secure the necessary 404 permit before issuing NTP to the D/B contractor.

- Right-of-Way and other agreements:
  - Right-of-Way: As described above. The area is quickly developing within project limits, with development happening more rapidly near the US 555 / SH 111 interchange. The cost estimate is based on today's estimated property values, but this might be insufficient to cover the increased values from planned developments.
  - Utilities: A number of utilities (e.g., City water and sewer, electric power, telecommunications fiber optic, and natural gas lines) are believed to cross the project, primarily beneath the proposed interchange. QDOT currently assumes (and estimates) that these utilities will be relocated at the utilities' expense. These relocations would occur in advance of construction and QDOT assumes that the utilities will relocate their lines in a timely manner. However, utility coordination is just getting started, and:
    - There is some indication that the telecommunication utility may seek a cost-sharing arrangement since it just completed the fiber-optic upgrade.
    - The City does not have money to relocate its water and sewer lines and might not be able to relocate in the time needed by the project. It is possible that the City will try to negotiate (with QDOT) a combined solution for relocation of the water and sewer lines and use of the sewer system by QDOT.
  - Railroad: None.
  - Other stakeholders: FHWA, the City, business owners, developers, travelling public, and residents.
- Procurement:
  - Delivery method: The project delivery method has not been selected, but the current assumption is a single Design/Build (D/B) contract to facilitate contractor innovation and to improve QDOT's chances of meeting its objectives for the project. QDOT might also employ contractor incentives to reward shortened construction schedule and minimized user impacts during construction (note: incentives are not included in the cost estimate; there is significant resistance by some within QDOT to using incentives with D/B procurement).
  - Contract packaging: See above.
  - Market (general and specialty): Current market conditions are uncertain. Because of the type and size of the project, and other projects currently underway or being bid, as well as the local contractor situation, QDOT anticipates four "good" proposals in response to its RFP, which could enhance competition. However, the successful proposals for two other recent QDOT Design/Build projects in this region bid higher costs than QDOT's internal estimates.
- Construction:
  - Construction access/restrictions (including seasonal, events, and workshifts): There are no significant restrictions along mainline US 555 and SH 111. Construction access and staging areas are good.

- Maintenance of traffic: To maintain mobility and minimize "user costs" (disruption) during construction, capacity equivalent to two lanes of US 555 and two lanes on SH 111 should be maintained during construction. However, QDOT anticipates that the contractor could propose alternatives, such as directional or full closures over short durations, to complete construction while minimizing disruption to the travelling public and minimizing construction schedule.
- Construction phasing: This has not been worked out in detail (QDOT does not know how the D/B contractor will build the project), but it is assumed that the interchange and roadway work can proceed simultaneously. QDOT hopes that the structures construction schedule can be minimized through use of ABC.

- Post-Construction ("Longevity"):
  - O&M: O&M for this roadway is expected to be typical, primarily involving periodic repaving (e.g., every ten years) and system (e.g., drainage system) maintenance as required. Such work can generally be done with limited lane closures and thus little disruption.
  - Replacement: Replacement of this roadway (especially structures) is anticipated to be required after about 50 years. Such replacement is expected to be very similar (in terms of activities and effort, and thus cost, schedule and disruption) to the current project, i.e., there are no elements that would be especially difficult to replace.

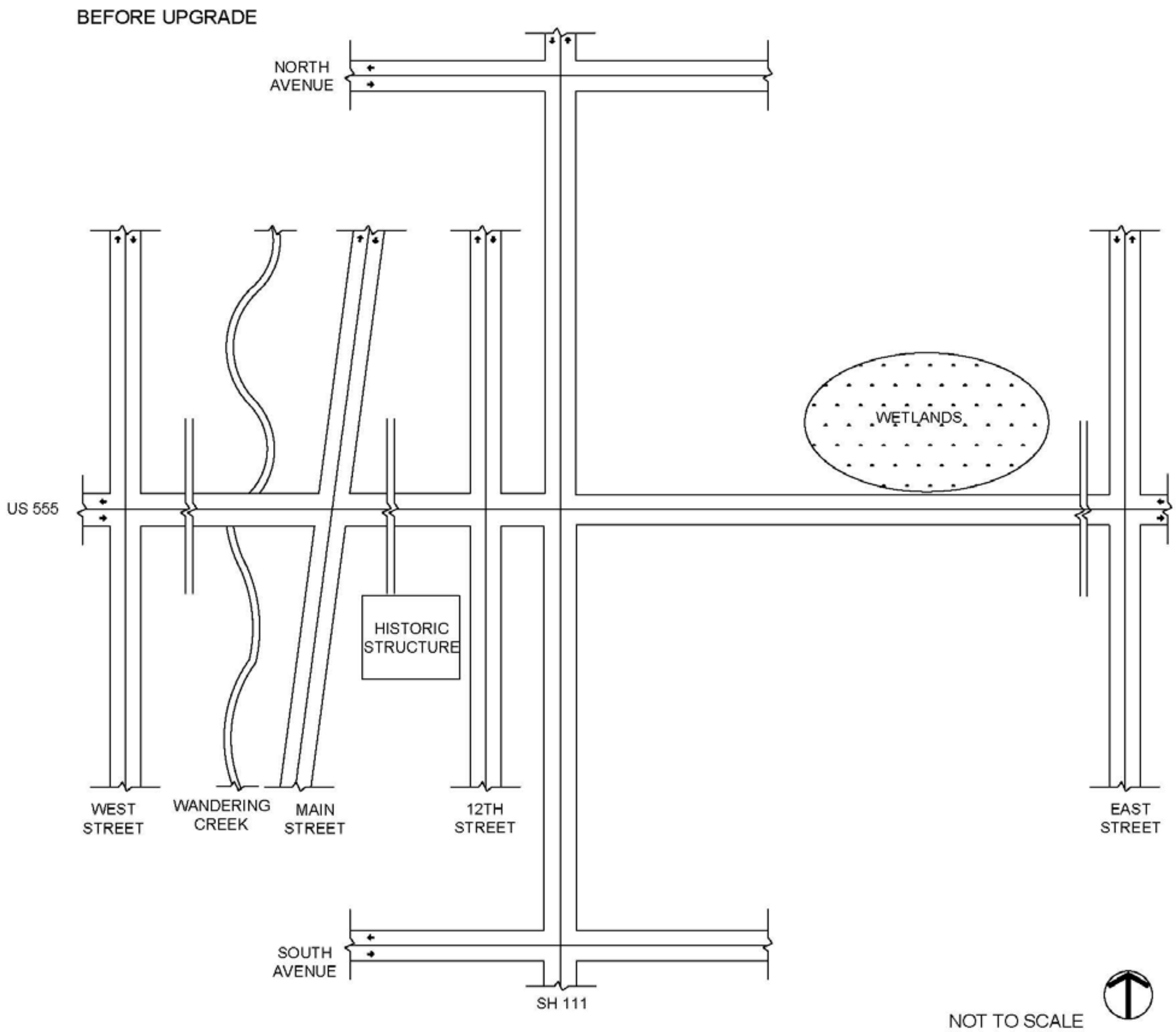


Figure A-1. QDOT US 555 / SH 111 Project Schematic: a) Before Upgrade

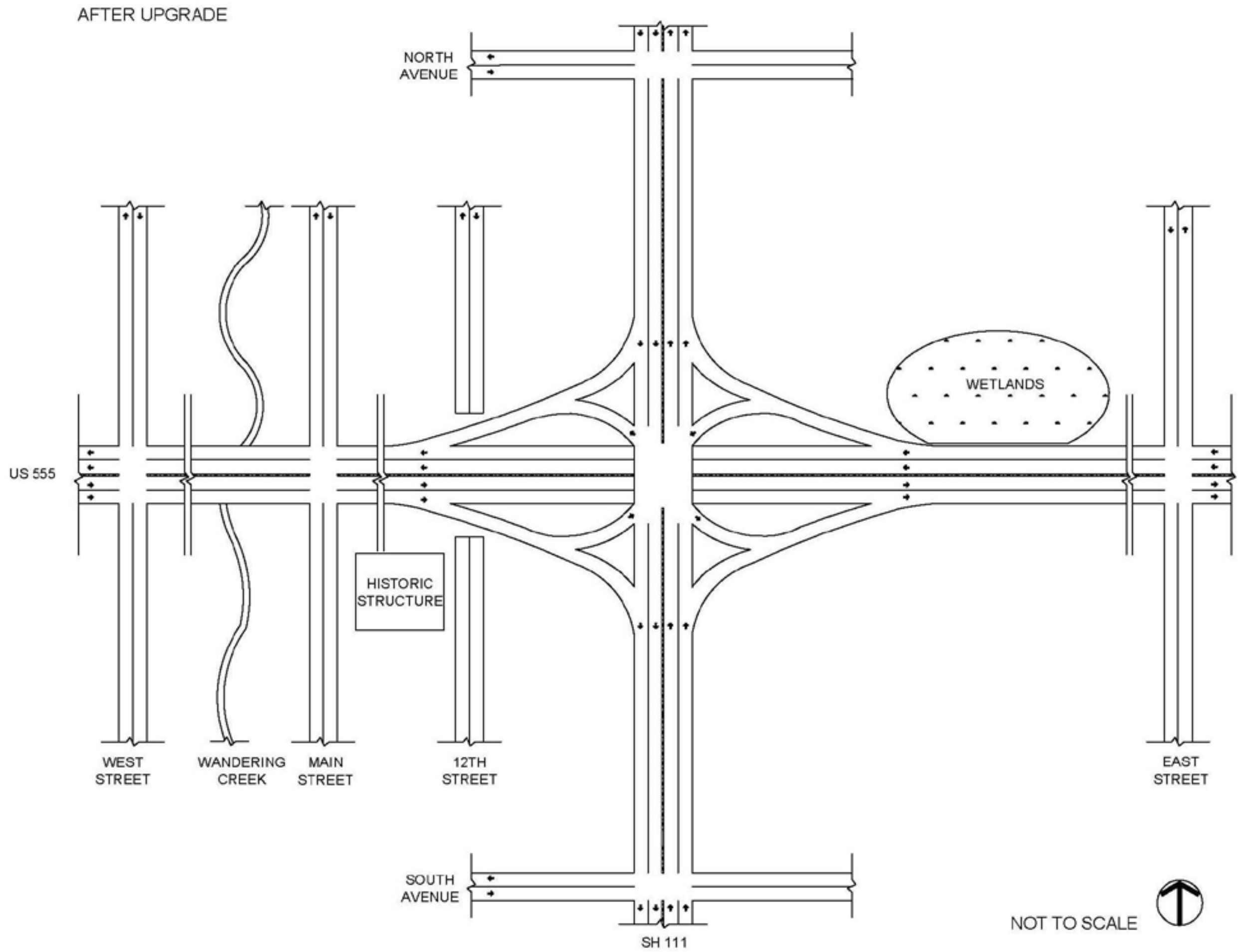


Figure A-1. QDOT US 555 / SH 111 Project Schematic: b) After Upgrade

Replacement of Bridge 702 PR-681, Arecibo Puerto Rico

Summary Project Description

Bridge 702 is located at PR-681 (Non-NHS System) km. 0.1 at the Municipality of Arecibo. The bridge crosses over Caño Tiburones cahnnel, Near Cienaga Tiburones, a state nature wildlife preserve. The bridge is located at a T intersection that connects PR-681 and PR-655.

PR-681 has an ADT of 7,600 (2015) and PR-655 1,100 (2015), the intersection is operating at F level on the weekends (traffic is the highest). Both roads are Two-lane highways, very narrow 6.50m width. The existing bridge is 10.977m of width because it has a provision for sugar cane rail.

Bridge 702 has a poor condition, especially the superstructure which has a rating of 4 according to the 2013 inspection report. The bridge beams and seats are severely corroded. This bridge is past its expected service life (built in 1955) and any rehabilitation alternative is crucial for the ability to maintain traffic over the Caño Tiburones during its replacement.

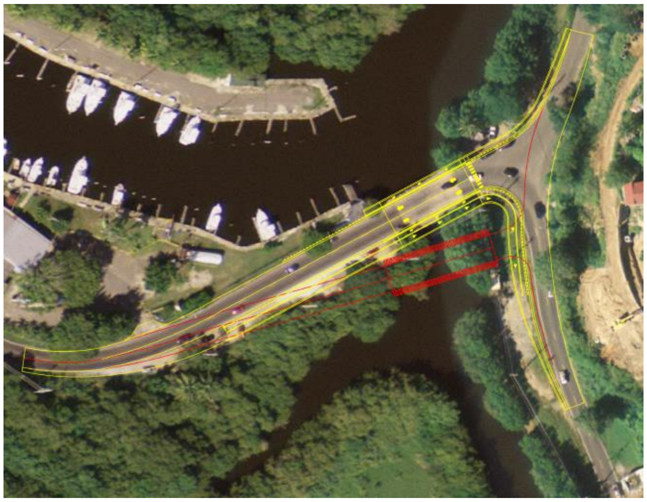
The overall of the goal of the replacement structure is to raise the profile to maximize drift clearance under the structure, minimize land acquisition, and maintain local access and connections while minimizing environmental impacts.

Project Scope, Strategy/Status, and Key Conditions and Assumptions

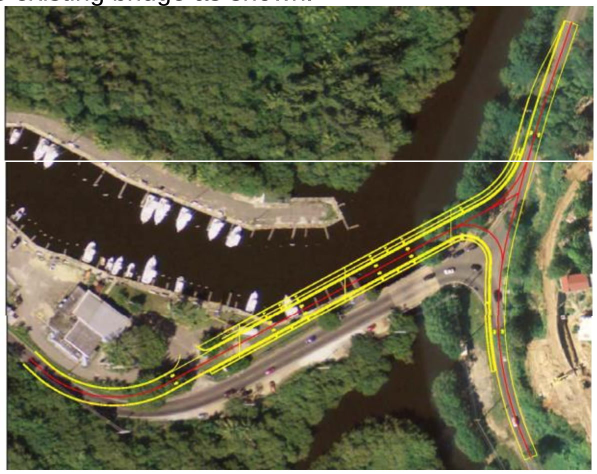
Alternatives, funding & Design

The design team analyzed had analyzed various alternatives to improve the bridge rating:

1. **Bridge rehabilitation:** The rehabilitation of the existing structure is a cost effective solution which minimizes construction time, environmental impacts, and disruption to existing traffic but also presents some design hurdles to be a viable option. A prior H&H study performed under the Bridge Program's Scour Evaluations project showed that the existing bridge is working at a borderline condition in terms of hydraulics, and extreme rain or flood events may have a negative impact on the bridge even though structurally it has been rehabilitated and its life extended. Also this bridge is the only access for Islote ward in Arecibo. In order to rehabilitate the bridge, this has to be closed. So a temporary bridge has to be constructed. The environmental and construction costs are the same as to replace the bridge, so this alternative was discarded from the beginning.



2. **Bridge replacement downstream:** This alternative considers an alignment located downstream to the northwest of the existing bridge as shown.



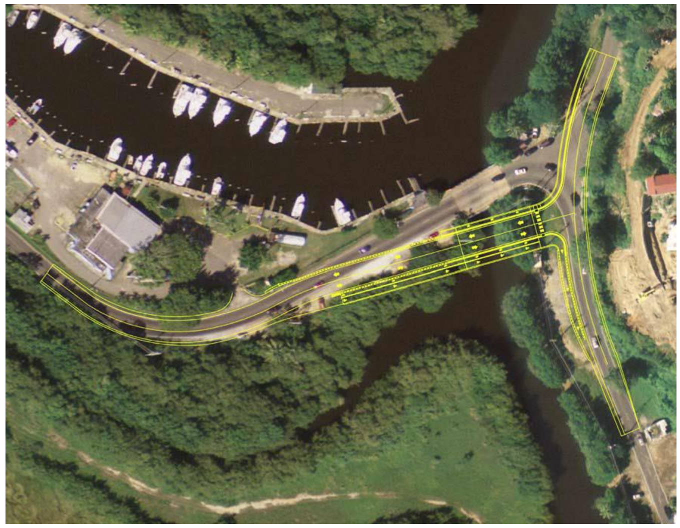
This alternative provides a brand new structure designed to recent codes and standards and incorporates current initiatives of the PRHTA, such as bicycle and pedestrian facilities in its cross section. In terms of construction, it will have extreme environmental impacts to the ecosystem and Caño Tiburones channel. This alternative considers a three span bridge with a total length of approximately 110 meters.

This alternative will not require a temporary overpass to maintain the traffic between Arecibo and Islote ward since the existing structure can be kept on service during the construction of the new bridge. The existing utilities attached to the existing bridge will be relocated to the proposed new bridge if it is determined that the existing structure must be removed.

No matter the alignment presented at this site (downstream) the proposed bridge that must be designed, need to negotiate with this flood area that is the widest in the zone under study. Also existing luxury yacht marina (at Northwest) will be impacted and require additional land acquisition. So the project would be more expensive and with more negative impacts than any one studied under "upstream alternatives".

3. **Bridge replacement upstream:** This alternative provides a brand new structure designed to recent codes and standards and incorporates current initiatives of the PRHTA, such as bicycle and pedestrian facilities in its cross section. In terms of construction, it will be similar to the temporary bridge since environmental impacts will be similar or almost identical since the proposed impact area is the same.

An alternate alignment for the new bridge just east of the current location of the existing bridge is proposed as shown. The proposed structure will have an approximate span length of 32m (single span).

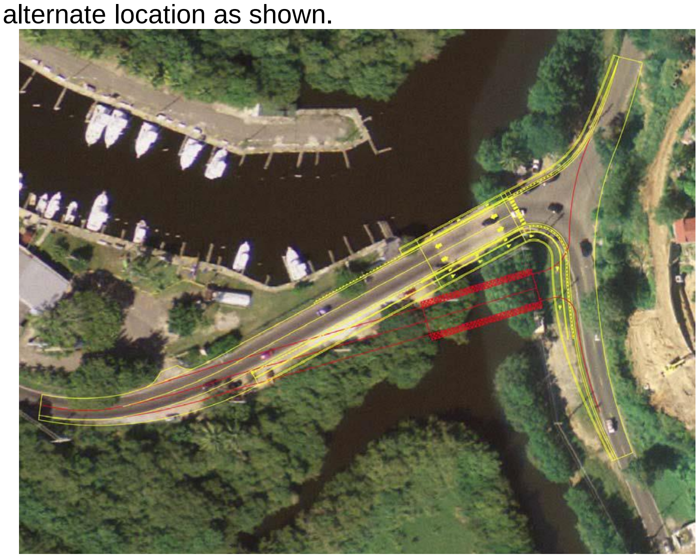


The span length and the potential need of an intermediate support will be determined at the final design based on the conclusion of the H&H study, so the minimum freeboard can be met without affecting the existing roadway grades.

Although precast abutments have not been discarded at this moment, they may not result in a cost-effective solution in this particular case since there is not a significant repetition of the structural components. The proposed substructure will consist of conventional CIP abutments with wing walls supported on steel H-piles or drilled shafts (depth foundation is anticipated based on preliminary geotechnical evaluation).

This alternative will not require a temporary overpass to maintain the traffic between Arecibo and Islote ward since the existing structure can be kept on service during the construction of the new bridge. The existing utilities attached to the existing bridge will be relocated to the proposed new bridge if it is determined that the existing structure must be removed.

4. **Bridge replacement upstream:** This alternative is considered only in the case that there is a restriction (environmental, land acquisition, etc.) in the possibility that the proposed bridge cannot be relocated to an alternate location as shown.



Given the many alternatives for temporary bridges, an ACROW bridge is suggested, which has been used successfully by the PRHTA on previous bridge replacement projects, which is an advantage, since the Authority is already familiar with the system. Should the Authority have one available for this project, the project would recognize significant savings for both construction and time. The challenge associated with this option is that the installation of the temporary bridge will increase environmental impacts in the area since construction of temporary abutments and embankments will need to be performed prior the installation of the bridge, and also the relocation of existing electrical distribution lines poses a challenge to the temporary bridge's preferred location.

The new structure will have an approximate single span length between 23m to 25m (to be confirmed by the H&H study) and will require the demolition of the intermediate support. The span length and the potential need of an intermediate support will be determined at the final design based on the conclusion of the H&H study, so the minimum freeboard can be met without affecting the existing roadway grades.

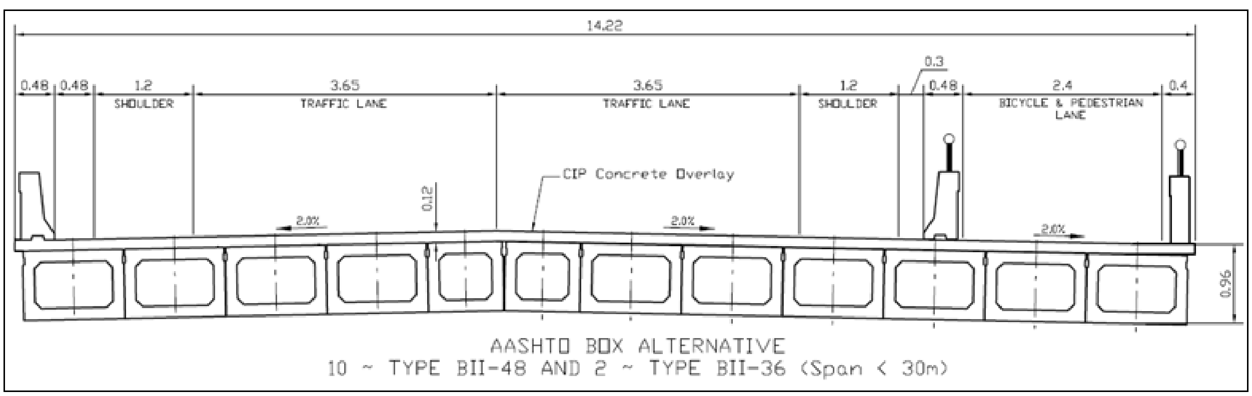
Precast abutments may not result in a cost-effective solution in this particular case since there is not a significant repetition of the structural components. The proposed substructure will consist of conventional CIP abutments with wing walls supported on steel H-piles or drilled shafts (depth foundation is anticipated based on preliminary geotechnical evaluation). This alternative will require a longer construction time since the existing structure will need to be removed first in order to construct the new bridge. The construction of a temporary overpass structure will also be required in order maintain the traffic open at all times.

The project is going to be funded with FHWA Critical Bridges program. The geotechnical study is not available yet but the area is composed of organic soils, so deep foundations and soil stabilization are expected.

The project is expected to use the existing superficial drainage system of the area, which consists of drainage channels. The area is susceptible to coastal flooding, so any H-H study will focus on this aspect.

Environment

PRHTA is currently evaluating what kind of document is needed for complying with NEPA process, since the project is at schematic level (12%). An Environmental Assessment is expected to be requested by FHWA Puerto Rico & US Virgin Islands Division. The proposed bridge section is as shown:



Environmental issues include several aspects: (a) land and structures acquisition: USACE Jurisdiction Permit; due to abutment construction; (b) Tree cutting permit must be obtained at DNER; (c) Cultural Resource Assessment will be endorsed by IPRC and SHPO; among others. PRHTA is working with these issues from project initiation as some of the permits and endorsements required for any of the alternatives take some time in the agencies.

- **USACE Jurisdictional Determination**

The areas surrounding the Bridge 702 have been heavily impacted during the past century. Debris from the old bridge and other previous structures remain along the channels and around the existing bridge abutments, and have changed the original soil characteristics, hydrology and ecological dynamics of the area. Mangrove trees have established in sediment that have accumulated among the debris. This debris does not provide a natural transition between uplands and wetlands/water channel in the area, or has been eliminated the existence of previous wetlands.

Based on the U.S. Department of Agriculture, Natural Resources Conservation Service USDA/NRCS) Soil Survey of the Arecibo Area of Puerto Rico (Version 6, Dec 20, 2013), the soils within the study area are Bajura clay (Ba), Cataño Sand (Ct) and Caracoles loam, 20-40% slope (CcE). Of these three, Bajura clay and Cataño Sand are classified as hydric soils.

Based on the Flood Insurance Rate Maps of the Federal Emergency Management Agency (FEMA), the bridge lies within a flood zone area. FEMA classifies this geographic area as Zone AE. According to the FEMA description, Zone AE has a high flood risk in which base flood elevations have been determined and represent a flooding area that can be kept free of encroachment, so that the 1% annual chance flood can be carried without substantial increases in flood heights.

According to the USFWS National Wetlands Inventory Map, there are two areas adjacent to the location of the project that are classified as wetlands. Areas west of Bridge 702 are currently not classified as wetlands, as the Arecibo Nautical Club has been built in this location. However, wetlands are present on the southeast end of the bridge, between PR-681 and the channel.

- **Flora and Fauna**

The Bridge No. 702 is located on the ecological life zone of Subtropical Moist Forests (Ewel and Whitmore, 1973). This is the most dominant life zone in Puerto Rico and the US Virgin Islands, covering 58% of the lands. It is characterized by an average annual precipitation between 39-89 inches and an average annual temperature of 64.4° to 75.2° F.

The areas surrounding Bridge No. 702 have been heavily impacted during the past century. Debris from the old bridge and other previous structures remain along the channels and around the existing bridge abutments, and have changed the original soil characteristics, hydrology and ecological dynamics of the area. Mangrove trees have established in sediments that have accumulated among the debris. This debris does not provide a natural transition between uplands and wetlands/water channel in the area, or has eliminated the existence of previous wetlands.

A total of 37 species of flora from 19 families were identified within the project site. 18 species of birds, 3 species of reptiles and 4 invertebrates were identified within the project site. Most of these species are typical of highly impacted areas. The area of the location of Bridge No. 702 area did not reveal the presence of any protected species of flora of high ecological value. However, 8 species of fauna currently listed as Threatened and/or Endangered under the Commonwealth and/or Federal scope are known to exist nearby; the brown pelican (Pelecanus occidentalis), roseate tern (Sterna dougallii), West Indian whistling duck (Dendrocygna arborea), ruddy duck (Oxyura jamaicensis), peregrine falcon (Falco peregrinus), masked duck (Nomonyx dominucus), Caribbean coot (Fulica caribaea) and the West Indian manatee (Trichechus manatus manatus).

- **Archeological**

The areas surrounding the Bridge 702 have been heavily impacted during the past century. Debris from the old bridge and other previous structures remain along the channels and around the existing bridge abutments, and have changed the original soil characteristics, hydrology and ecological dynamics of the area. Bridge 702 is located on road PR-681 in the area known as Caño Tiburones, which is the largest wetland in Puerto Rico.

The archaeology and “etnohistoria” program of the Institute of Puerto Rican Culture and the Office State Historic Preservation will require an archaeological assessment Phase I (Parts A and B) for the development of the project: Replacement Bridge # 702, located in the neighborhood Islet, of the municipality of Arecibo. The archeological shall meets the requirements of the archaeological assessment designed by Institute of Puerto Rican Culture, the State Historic Preservation Office, Law 112 that regulates the study and protection of the earth's archaeological heritage, and according to the statutes of the federal "National Historic Preservation Act (Section 106)" and "Protection of Historic and Cultural Properties (36 CFR Part 800)".

- **Presence of Asbestos Material and Lead-Based Paint**

Existing bridge have been tested for asbestos or lead-based paint presence. A total of twenty four (24) testing combinations were tested using NITON 300XLp Series X-Ray Fluorescence instrument (XRF) manufactured by NITON Corporation. Using EPA Method 6200, the XRF instrument was set at Standard Paint Mode showing reading “Positive” or “Negative” with a 95% confidence level reading. Lead Based Paint was found in the whole Bridge structure and the yellow traffic lines (excluding green and gray pipe line).

Asbestos-containing material (ACM) is defined as any material or product which contains more than 1 percent asbestos. A survey of the existing bridge was conducted considering (as reference only) the most recent protocol for assessing asbestos containing materials (40 CFR 763E). Survey did not find any material suspected to contain asbestos fibers during the inspections. No SACM samples were collected; therefore Asbestos Containing Material was not detected in the structures.

- **Habitat Certification**

Bridge 702 is located on road PR-681 in the area known as Caño Tiburones, which is the largest wetland in Puerto Rico. This bridge crosses the principal channel of Caño Tiburones, which flows west into the Atlantic Ocean, approximately 450 meters downstream from the bridge.

The entire bridge area has been paved and impacted by manmade structures. The existing vegetation on the project site is located along the road (PR-681) and along the banks of the main drainage channel of Caño Tiburones. Most of the existing vegetation is associated to the drainage channels and the wetland areas closer to the bridge.

No habitat of Ecological Value will be impacted. A reforestation plan will be developed in the area after the construction work is finalized which will create a buffer zone protecting the water body from anthropogenic activities carried out in the area.

- **Tree Inventory**

A total of 181 trees belonging to 12 species were identified within the limits of project. The most abundant species was the white mangrove (*Laguncularia racemosa*) and the portia tree (*Thespesia populnea*). None of the trees that were identified in the area are listed as Threatened or Endangered under State and/or Federal scope.

Right of way and other agreements

- The closest properties to the project site are the Club Nautico de Arecibo to the Northwest and DOT and PREPA properties to the South. Depending on the on the alternative selected during the NEPA process, acquisition may be need it.

- Various utilities area present on the project area: aerial power lines, underground telephone fiber optic lines, potable and sewer water lines, and a fuel line that serves PREPA.

- No railroad is operational in Puerto Rico.

- A US Coast Guard Permit will be required since Caño Tiburones is a navigable channel.

- The Islote community is very active. They have been opposing the construction of a waste to energy power plant proposed on the area. So anything proposed on Islote will be very closely monitored by that community.

Procurement

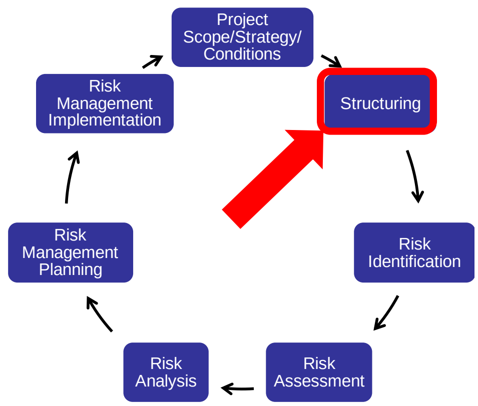
- The project will be develop by the Design-Bid-Build method, since is a small project. The project will be bid in one package.

- The projected working hours during construction would be from 7:00am to 5:00pm. No night time construction is expected.

- Depending on the on the alternative selected during the NEPA process, is how the MOT will be done. Is the replacement is in place, a temporary bridge will be needed to maintain traffic. If the bridge is replaced downstream or upstream, the existing bridge could be used for traffic maintenance.

- The construction phasing will depend on the alternative selected during the NEPA process. As a general rule:
  - Construction of temporary bridge (if replace on place)
  - Temporary relocation of utilities
  - Construct new bridge
  - Shift traffic to new bridge
  - Demolish the existing bridge

Module 4: Structuring the Project for Risk Management



4-1

Structuring for Risk Management

- **Learning Outcomes**
- Define Structuring
- Define base project
- QDOT Case Study
- Summary

4-2

Learning Outcomes

- Explain the role and importance of Structuring
- Define base for project under assumed conditions (e.g. base cost and base schedule)
- Illustrate the Structuring step on the R09 Risk Template

4-3

Structuring for Risk Management

- Learning Outcomes
- **Define Structuring**
- Define base project
- QDOT Case Study
- Summary

4-4

What is Structuring?

- Defining base project scenario, against which risk and opportunity can be identified, assessed, and eventually managed

4-5

Why Structuring?

Structuring project for risk management:

- Defines and documents base for risks and for future reference
- Clarifies project scope, strategy, and key conditions and assumptions
- Develops common understanding of project
- Confirms consistency of scope, strategy, cost, schedule, and disruption estimates

4-6

Structuring for Risk Management

- Learning Outcomes
- Define Structuring
- **Defining base project**
- QDOT Case Study
- Summary

4-7

Defining Base Project

The base project is the planned project if it goes as originally assumed

- Base = planned performance associated with a particular set of assumptions w/o contingency, escalation, and float
- Risk or opportunity = events and conditions that may/may not occur and may produce changes in performance associated with other possible future scenarios
- Total = base + risk (combined conditions)

Note: Base is variable through project life

4-8

Project Changes Over Time

- Changes in base and/or risk and opportunities due to:
  - Project development
  - Changing conditions
  - Unplanned events and new information
- Risks eventually either occur (become base), occur and are partially mitigated (residual risk), or do not occur (go away)
- Hence, there's a need to establish and control contingency for collective residual risks

4-9

Base project elements

1. Planned project scope
2. Key conditions and assumptions
3. Planned delivery strategy
4. Cost, schedule, and disruption estimates stripped of contingency

4-10

1. Planned Project Scope

- Develop/document list of planned scope elements (e.g. pavement reconstruction, bridge replacement)
  - Project development and delivery
  - Operations & Maintenance (if desired)
- Leave out optional scope items which might become risks
- Exclude contingencies

4-11

2. Key Conditions

- Develop/document comprehensive list of key conditions (facts), requirements, and constraints
  - Conditions
    - Technical - existing infrastructure and potential interfaces (transportation, utilities, etc.)
    - Political - stakeholders
  - Requirements and constraints
    - Environmental commitments (e.g. wetland mitigation)
    - Regulatory requirements (e.g. limit of access)

4-12

2. Key Assumptions

- Develop/document comprehensive list of key assumptions (not facts)
- Examples:
  - Funding availability
  - Structures types
  - Number of lanes to be added

4-13

3. Planned Delivery Strategy Flowchart Development

- Develop/document list of strategy elements
  - Strategy elements consists of:
    - Delivery method (D-B , D-B-B, CMGC)
    - Env. documentation/process
    - Contracting mechanism (type, number, size of contracts)
    - Funding source (private, public. combined)
    - Construction phasing
- Develop a Flowchart and document the sequence of activities and its logic

4-14

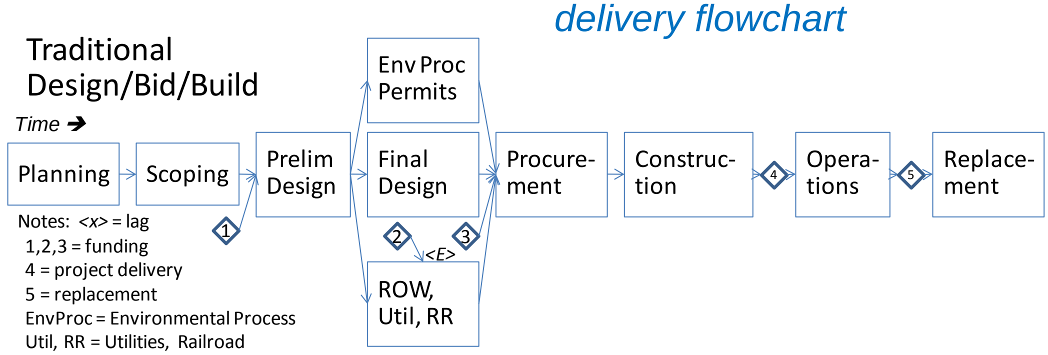
3. Planned Delivery Strategy Flowchart Development (cont.)

- Guidance for Flowchart development:
  - Appropriate level of detail (key decision points)
  - Comprehensive and non-overlapping set of activities, milestones, decision points
  - Complete schedule logic (all precedence requirements)
  - Graphical schematic with specific format
  - Delivery method: Design-Build vs. Design-Bid-Build

4-15

3. Planned Delivery Strategy D-B-B Flowchart

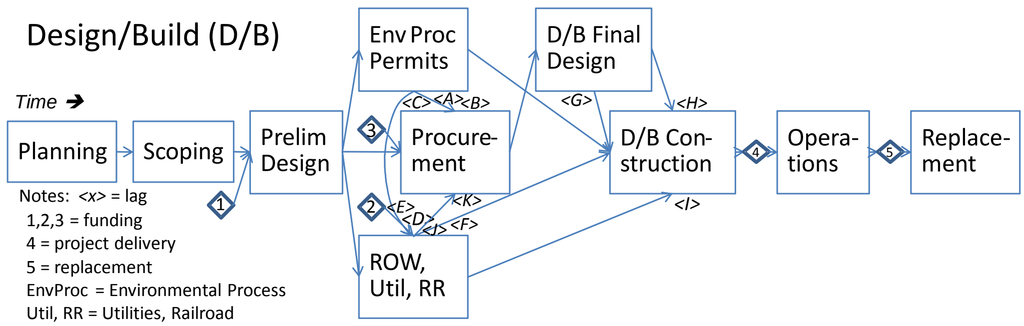
Pick/define simplified project delivery flowchart



4-16

3. Planned Delivery Strategy D-B Flowchart

Pick/define simplified project delivery flowchart



Note: D/B flowchart considers overlap between end of Preliminary Design and end of D/B Construction

4-17

4. Base **Cost** Estimate

- Develop/document costs for base project:
  - Appropriate level of detail and organization
  - Comprehensive and non-overlapping set of cost items
  - No line-item or global contingencies
  - No conservatism in unit prices, quantities, etc. (unbiased)
- Allocate costs to flow chart activities (to develop cost-loaded schedule)

4-18

4. Base **Cost** Estimate - Example

Line items	Quantities	Unit	Total Cost	
ROW				
ROW	x sf	$/sf	$	e.g, appraised or avg cost/sf
condemn/admin	sum	%	$	
<contingency/risk>			$	
escalation	sum	%(t)	$	function of schedule (incl delays)
subtotal			$	
CONSTRUCTION				does unit cost incl Contractor OH/profit or not (and thus separate line item)?
A	x sf	$total/x sf	A1+A2+A3	composite (incl all markups or not?)
A.1			$	
A.2			$	
A.3			$	
B			$	
C			$	
D			$	
E	A+B+C	%	$	e.g., allowance
<contingency/risk>			$	in bid
assumed escalation	sum	%(t)	$	function of planned schedule
mob	sum	%	$	
sales tax	sum	%	$	
subtotal (bid)			$	
<contingency/risk>			$	not in bid (includes escalation and sales tax, and other markups?)
ENGINEERING/MANAGEMENT				
PE	sum	%	$	incl PM preCN - note % used is not % of total project cost (applied to subtotal)
CE	sum	%	$	incl PM during CN
other	sum	%	$	e.g., DPS, TDM, etc
<contingency/risk>			$	e.g., extended OHs
escalation	sum	%(t)	$	function of schedule (incl delays) - depends on whether quantity is escalated or not
subtotal			$	
TOTAL (YOE)			$	

4-19

4. Base Cost Estimate - Example

DESCRIPTION	UNIT	UNIT COST	TOTAL ESTIMATED QUANTITY	COST PER TOTAL QUANTITY (2015 $)
MOB (5% max)	**LS**	**5.74%**		**$2,200,000**
REMOVALS	**LS**	**4.70%**		**$1,200,000**
TOPSOIL BORROW (CV)	C Y	$20.00	20,487.0	$409,740
EXCAVATION - COMMON PONDS	C Y	$6.5[illegible]	26,9[illegible]7.0	$175,[illegible]
EXCAVATION - COMMON	C Y	$6.5[illegible]	236,354.0	$1,536,301
EXCAVATION SUBGRADE	C Y	[illegible]	[illegible],412.0	$513,[illegible]
COMMON EMBANKMENT (CV) PONDS	C Y	$3.26	131.0	$427
COMMON EMBANKMENT (CV)	C Y	$3.26	1,892.0	$6,168
GRANULAR EMBANKMENT (CV)	C Y	$14.00	63,801.0	$893,214
SELECT GRANULAR EMBANKMENT (CV)	C Y	$14.00	72,214.0	$1,010,996
WATER	MGAL	$30.00	100.0	$3,000
CALCIUM CHLORIDE SOLUTION	GAL	$1.00	2,000.0	$2,000
Grading		**11.88%**		**$4,550,026**
AGGREGATE BASE CLASS	CU YD	$26.00	34,150.0	$887,900
Base Construction		**2.32%**		**$887,900**
MILL BITUMINOUS SURFACE (2.0")	S Y	$2.50	48,613.0	$121,533
TYPE SP 12.5 NON WEAR COURSE MIX	TON	$75.00	686.6	$51,495
Bituminous Pavement		**0.45%**		**$173,028**
1.5" DOWEL BAR	EACH	$10.00	20,064.0	$200,640
1.5" DOWEL BAR (STAINLESS STEEL)	EACH	$15.20	69,399.0	$1,054,865
CONCRETE PAVEMENT 10.5"	S Y	$64.34	146,599.0	$9,432,180
CONCRETE PAVEMENT 9"	S Y	$67.85	21,911.0	$1,486,661
CONCRETE PAVEMENT 7"	S Y	$55.00	49,714.0	$2,734,270
SUPPLEMENTAL PAVEMENT REINFORCEMENT (EPOXY COATED)	LB	$2.00	*****	$20,000
Concrete Pavement		**38.97%**		**$14,928,616**
Modular Block Retaining Wall	SF	$65	4,700.0	$305,500
24" RC Pipe Apron	Each	$675	6.0	$4,050
36" RC Pipe Apron	Each	$1,240	8.0	$9,920
42" RC Pipe Apron	Each	$1,295	1.0	$1,295
12" TP Pipe Drain	LF	$30	285.0	$8,550
8" Perf PE Pipe Drain	LF	$10	2,670.0	$26,700
15" RC Pipe Sewer	LF	$36	15,500.0	$558,000
18" RC Pipe Sewer	LF	$45	17,400.0	$783,000
24" RC Pipe Sewer	LF	$52	960.0	$49,920
36" RC Pipe Sewer	LF	$75	530.0	$39,750
42" RC Pipe Sewer	LF	$94	320.0	$30,080
15" PVC Slotted Drain	LF	$115	3,600.0	$414,000
SPCD	Each	$50,000	6.0	$300,000
Const Drainage Structure Design G	Each	$1,300	22.0	$28,600
Const Drainage Structure Design Special	Each	$10,000	4.0	$40,000
Const Drainage Structure Des SD	Each	$3,000	166.0	$498,000
Const Drainage Structure Des 72-4020	Each	$7,000	18.0	$126,000
Concrete Curb & Gutter Design D424	LF	$13	20,950.0	$272,350
Filter Topsoil Borrow	CY	$45	8,410.0	$378,450
DRAINAGE		**10.11%**		**$3,874,165**
TRAFFIC	**LS**	**3.13%**		**$1,200,000**
CONC MED BAR & GL SCR DES 8309 TYPE A	LIN FT	$70.00	14,500.0	$1,015,000
Concrete Median Barriers		**2.65%**		**$1,015,000**
CONCRETE ITEMS	LS	0.57%		$220,000
TURF AND EROSION CONTROL	LS	2.09%		$800,000
MISC- SIGNING, FENCING, ETC.	LS	2.09%		$800,000
BRIDGE	LS			$1,300,000
MISC- LIGHTING	LS			$665,600
SIGNAL SYSTEM COST	LS			$155,000
NOISE WALL	SQ FT	$20.00		$823,000
PED RAMPS (ADA)	EACH	$5,000.00	16	$80,000
TMS	LS			$500,000
OHS	LS			$547,000
TRAFFICE MITIGATION (Staging bypass)	LS			$1,785,075
TOTAL				**$38,304,410**

Note: Unit prices and quantities do not contain any contingency.

4-20

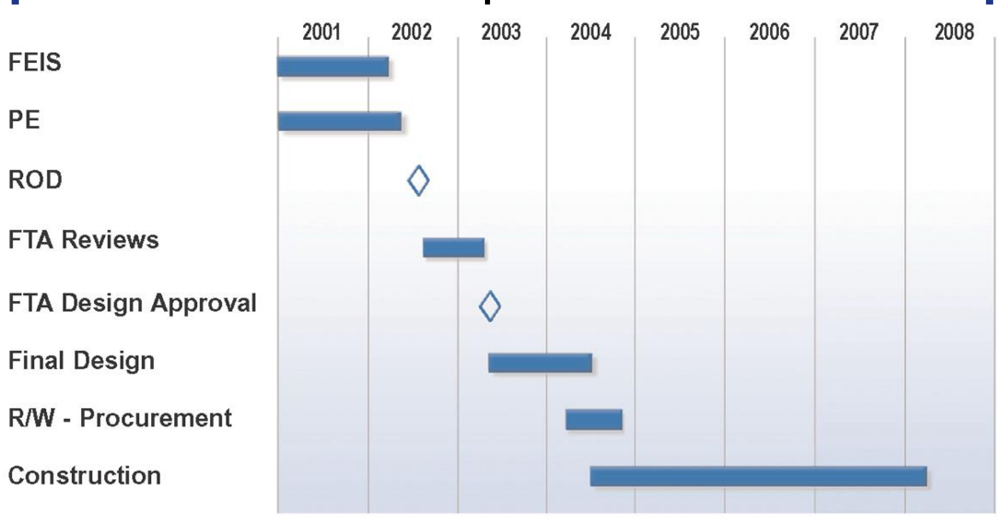
4. Base **Schedule** Estimate

Develop/document schedule for base project

- Using key target dates / milestones
- Removing schedule contingency (float)
  - Float: Anticipated actual duration for each activity with conservatism, biased risk or opportunity
- Basing it on critical path analysis and key milestones

4-21

4. Base **Schedule** Estimate - Example



4-22

4. Base **Disruption** Estimate

- Disruption: a measure of project performance expressed in terms of the amount of hours lost by the public, which when combined with an average cost per hour produces user cost.

4-23

4. Base **Disruption** Estimate (cont.)

- How does your DOT typically estimates traffic disruption?

- Disruption example:

  10% of construction activity (1,000 days) x

  10,000 people / day x 1 hr./person = 1 million-hrs.

- Note: Disruption Value (RUC) is determined by the DOT according to their disruption data.

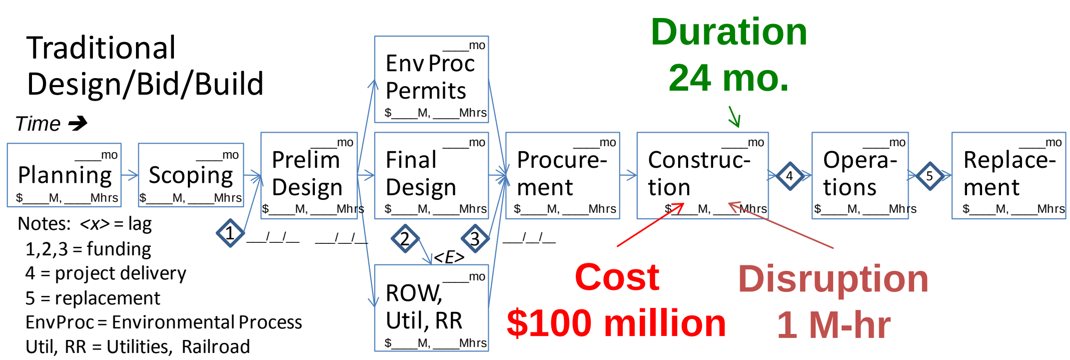
4-24

4. Base **Disruption** Estimate (cont.)

- Develop/document disruption for base project
  - Identify affected project activities
  - Estimate (anticipated actual and unbiased)
    - Affected activity duration (days)
    - Affected population (persons/day)
    - Delay (hrs./person)

4-25

Base Performance Estimate
D-B-B (*Guide* App E)



4-26

Other Structuring factors

- Escalation rates
  - Mean base schedule (date, float),
  - Mean base cost (un-inflated, inflated), and
  - Mean base disruption (person-hours)
- Overhead Rates (Preconstruction & Construction)
- Schedule value ($/months of delay)
- Disruption value (considering user costs)

4-27

Structuring for Risk Management

- Learning Outcomes
- Define Structuring
- Defining base project
- **QDOT Case Study**
- Summary

4-28

QDOT Case Study for Structuring-Instructions

1. Quickly review your observations from Attachment A- QDOT Project Description Form (Module 3 Exercise).

2. Review Attachment B- QDOT base project performance (cost, schedule, disruption) located at the end of Module 4.

4-29

QDOT Case Study for Structuring-Instructions (cont.)

3. Open to the R09 Risk template file. Click on Step 1- Structuring.

4. Complete the project structuring sheet (on template) using the information from your ***Module 3 Case Study observations and Attachment B.***

4-30

QDOT Case Study for Structuring-Instructions (cont.)

5. Enter information ONLY on the following menus
   - "Create project" (select delivery method, select whether OMR will be part of the analysis, select whether Disruption will be part of the analysis),
   - Schedule (activity durations),
   - Cost (enter cost per activities, overhead rates, escalation rates)
6. Instructors present full results (slides 32-34)

4-31

Case Study Results – Base Cost

BASE COST (in Current Year and Year of Expenditure Dollars)

Project Phase	Base Cost (CY $M)	Base Cost + Overhead Cost (CY $M)	Base Cost + Overhead Cost (YOE $M)
Planning		0.00	0.00
Scoping		0.00	0.00
Design/Environmental Process	1.19	1.19	1.21
Environmental Permits		0.00	0.00
ROW/Util/RR	3.00	3.00	3.14
Procurement		0.00	0.00
Final Design		0.00	0.00
Construction	11.85	11.85	12.67
Total	16.04	16.05	17.02

Cost Inflation Rate (percent/year)	
Preconstruction	3.0
ROW/Utility/RR	3.0
Construction	3.0

Overhead Rate	(CY $ M/month)
Preconstruction	0.10
Construction	0.23

4-32

Case Study Results – Base Disruption

DISRUPTION				
Disruption Value		10	$M/M-hr	
Agency/User Cost Discount Factor		1		

Project Phase	Disruption			
	M Veh-Hours/Day	No. of Days	M-Hrs	Cost ($M)
Planning			0.0	0.0
Scoping			0.0	0.0
Design/Environmental Process			0.0	0.0
Environmental Permits			0.0	0.0
ROW/Util/RR	0.02	10	0.2	2.0
Procurement			0.0	0.0
Final Design			0.0	0.0
Construction	0.05	10	0.5	5.0
Operations & Maintenance			1.4	14.0
Replacement			0.7	7.0
Total Disruption through OMR			2.8	28.0

4-33

Case Study Results – Base Schedule & Summary

SUMMARY

Project Phase	Total CY Cost ($M)	Total YOE Cost ($M)	Duration (months)	Early Start	Early Finish
Planning		0.00	0	12/1/2009	12/1/2009
Scoping		0.00	0	12/1/2009	12/1/2009
Prelim Design/Environmental Process	1.19	1.21	12	12/1/2009	11/30/2010
Environmental Permits		0.00	6	11/30/2010	6/1/2011
ROW/Util/RR	3.00	3.14	12	11/30/2010	11/30/2011
Final Design		0.00	6	6/1/2011	11/30/2011
Procurement		0.00	6	11/30/2010	6/1/2011
Construction	11.85	12.67	16	7/1/2011	10/30/2012
Operations & Maintenance	0.00	0.00	600	10/30/2012	10/30/2062
Replacement	0.00	0.00	0		

Base Cost (YOE $M)	17.02	(through Operations, Maintenance, & Replacement)
Base Construction Completion Date	10/30/2012	
Months to Construction Completion	35.00	
Base Disruption ($M)	18.70	(through Operations, Maintenance, & Replacement)

4-34

Structuring for Risk Management

- Learning Outcomes
- Define Structuring
- Defining base project
- QDOT Case Study
- **Summary**

4-35

Summary

- Defined Structuring
- Discussed the purpose and importance of Structuring
- Defined base for project under assumed conditions (e.g. base cost, base schedule, and base disruption)
- Illustrated the Structuring step on the R09 Risk Template

4-36

Summary (cont.)

- Discussed Structuring benefits:
  - Clarifies and develops common understanding of project
  - Aids communication within and outside the team
  - Provides basis for risk and opportunity analysis

4-37

Questions?

goSHRP2@dot.gov

SHRP2 SOLUTIONS

Save lives. Save money. Save time.

4-38

Table 4-19 Base Cost Estimate

Line items	Quantities	Unit	Total Cost	
ROW				
ROW	x sf	$/sf	$	e.g, appraised or avg cost/sf
condemn/admin	sum	%	$	
<contingency/risk>			$	
escalation	sum	%(t)	$	function of schedule (incl delays)
subtotal			$	
CONSTRUCTION				does unit cost incl Contractor OH/profit or not (and thus separate line item)?
A	x sf	$total/x sf	A1+A2+A3	composite (incl all markups or not?)
A.1			$	
A.2			$	
A.3			$	
B			$	
C			$	
D			$	
E	A+B+C	%	$	e.g., allowance
<contingency/risk>			$	in bid
assumed escalation	sum	%(t)	$	function of planned schedule
mob	sum	%	$	
sales tax	sum	%	$	
subtotal (bid)			$	
<contingency/risk>			$	not in bid (includes escalation and sales tax, and other
ENGINEERING/MANAGEMENT				
PE	sum	%	$	incl PM preCN - note % used is not % of total project cost (applied to subtotal)
CE	sum	%	$	incl PM during CN
other	sum	%	$	e.g., DPS, TDM, etc
<contingency/risk>			$	e.g., extended OHs
escalation	sum	%(t)	$	function of schedule (incl delays) - depends on whether quantity is escalated or not
subtotal			$	
TOTAL (YOE)			$	

Table 4-20: Sample Base Cost Estimate

DESCRIPTION	UNIT	UNIT COST	TOTAL ESTIMATED QUANTITY	COST PER TOTAL QUANTITY (2015 $)
MOB (5% max)	**LS**	**5.74%**		**$2,200,000**
REMOVALS	**LS**	**4.70%**		**$1,200,000**
TOPSOIL BORROW (CV)	C Y	$20.00	20,487.0	$409,740
EXCAVATION - COMMON PONDS	C Y	$6.50	26,937.0	$175,091
EXCAVATION - COMMON	C Y	$6.50	236,354.0	$1,536,301
EXCAVATION - SUBGRADE	C Y	$7.50	68,412.0	$513,090
COMMON EMBANKMENT (CV) PONDS	C Y	$3.26	131.0	$427
COMMON EMBANKMENT (CV)	C Y	$3.26	1,892.0	$6,168
GRANULAR EMBANKMENT (CV)	C Y	$14.00	63,801.0	$893,214
SELECT GRANULAR EMBANKMENT (CV)	C Y	$14.00	72,214.0	$1,010,996
WATER	MGAL	$30.00	100.0	$3,000
CALCIUM CHLORIDE SOLUTION	GAL	$1.00	2,000.0	$2,000
Grading		**11.88%**		**$4,550,026**
AGGREGATE BASE CLASS	CU YD	$26.00	34,150.0	$887,900
Base Construction		**2.32%**		**$887,900**
MILL BITUMINOUS SURFACE (2.0")	S Y	$2.50	48,613.0	$121,533
TYPE SP 12.5 NON WEAR COURSE MIX	TON	$75.00	686.6	$51,495
Bituminous Pavement		**0.45%**		**$173,028**
1.5" DOWEL BAR	EACH	$10.00	20,064.0	$200,640
1.5" DOWEL BAR (STAINLESS STEEL)	EACH	$15.20	69,399.0	$1,054,865
CONCRETE PAVEMENT 10.5"	S Y	$64.34	146,599.0	$9,432,180
CONCRETE PAVEMENT 9"	S Y	$67.85	21,911.0	$1,486,661
CONCRETE PAVEMENT 7"	S Y	$55.00	49,714.0	$2,734,270
SUPPLEMENTAL PAVEMENT REINFORCEMENT (EPOXY COATED)	LB	$2.00	*****	$20,000
Concrete Pavement		**38.97%**		**$14,928,616**
Modular Block Retaining Wall	SF	$65	4,700.0	$305,500
24" RC Pipe Apron	Each	$675	6.0	$4,050
36" RC Pipe Apron	Each	$1,240	8.0	$9,920
42" RC Pipe Apron	Each	$1,295	1.0	$1,295
12" TP Pipe Drain	LF	$30	285.0	$8,550
8" Perf PE Pipe Drain	LF	$10	2,670.0	$26,700
15" RC Pipe Sewer	LF	$36	15,500.0	$558,000
18" RC Pipe Sewer	LF	$45	17,400.0	$783,000
24" RC Pipe Sewer	LF	$52	960.0	$49,920
36" RC Pipe Sewer	LF	$75	530.0	$39,750
42" RC Pipe Sewer	LF	$94	320.0	$30,080
15" PVC Slotted Drain	LF	$115	3,600.0	$414,000
SPCD	Each	$50,000	6.0	$300,000
Const Drainage Structure Design G	Each	$1,300	22.0	$28,600
Const Drainage Structure Design Special	Each	$10,000	4.0	$40,000
Const Drainage Structure Des SD	Each	$3,000	166.0	$498,000
Const Drainage Structure Des 72-4020	Each	$7,000	18.0	$126,000
Concrete Curb & Gutter Design D424	LF	$13	20,950.0	$272,350
Filter Topsoil Borrow	CY	$45	8,410.0	$378,450
DRAINAGE		**10.11%**		**$3,874,165**
TRAFFIC	**LS**	**3.13%**		**$1,200,000**
CONC MED BAR & GL SCR DES 8309 TYPE A	LIN FT	$70.00	14,500.0	$1,015,000
Concrete Median Barriers		**2.65%**		**$1,015,000**
CONCRETE ITEMS	LS	0.57%		$220,000
TURF AND EROSION CONTROL	LS	2.09%		$800,000
MISC- SIGNING, FENCING, ETC.	LS	2.09%		$800,000
BRIDGE	LS			$1,300,000
MISC- LIGHTING	LS			$665,600
SIGNAL SYSTEM COST	LS			$155,000
NOISE WALL	SQ FT	$20.00		$823,000
PED RAMPS (ADA)	EACH	$5,000.00	16	$80,000
TMS	LS			$500,000
OHS	LS			$547,000
TRAFFICE MITIGATION (Staging bypass)	LS			$1,785,075
TOTAL				**$38,304,410**

Note: Unit prices and quantities do not contain any contingency.

ATTACHMENT B. BASE PROJECT PERFORMANCE

Project performance of interest generally consists primarily of:

- Schedule (especially through construction)
- Cost (both unescalated and escalated, especially through construction)
- Disruption (especially through construction)
- Longevity (combination of schedule, cost and disruption after construction)

Such performance is a combination of “base” (without risk) and “risk” components. This attachment discusses the base component; the risk component is discussed in Attachment C. The base component is typically derived from project team estimates (e.g., of schedule, cost, disruption, etc.), which are reviewed and possibly revised to remove any bias (e.g., conservatism) and stripped of any other contingency (which will be replaced by the “risk” component). However, only performance through construction is focused on for now.

Project Schedule Estimate

The current project schedule estimate consists of the following key elements (as of 01 Dec 2009):

- Remaining prelim design / environmental process - 12 months long
- Environmental permitting – 6 months long, starts after prelim design / environmental process is done
- ROW/utilities/RR – 12 months long
    - o starts after prelim design / environmental process is done
    - o can’t finish until environmental permitting is done and ROW funding is available,
- Procurement - 6 months long
    - o starts after prelim design / environmental process is done and construction funding is available
    - o can’t finish until environmental permitting is done and ROW/utilities/RR is at least half done (6 months left, i.e., QDOT is prioritizing ROW acquisition to get key parcels before issuing NTP to contractor; hence, procurement can finish when only half the ROW acquisition remains)
- D/B design – 6 months long, starts after procurement is done
- D/B construction – 16 months long
    - o starts after environmental permitting is done and at least 1 month after start of D/B design and with no more than 6 months remaining of ROW/util/RR
    - o can’t finish until at least 6 months after end of D/B design and at least 10 months after end of ROW/utility/RR
- Operations – 50 yrs long, starts after construction done
- Replacement – 2 yrs long, start after operations done

Project Cost Estimate

The current project cost estimate (through construction) is shown in Table B-1. For post-construction, operations & maintenance costs average about $0.5 million per year and replacement costs are about the same as the current project delivery costs ($16 million), all in 2009$..

Project Disruption Estimate

The current project disruption estimate is shown in Table B-2.

Base Project Performance

The various inputs for the standard simplified D/B flowchart for this project (see Figure 2-1) are summarized in Table B-3, in which they are used to calculate mean project performance (by activity and collectively): cost (unescalated and escalated), schedule (milestone dates), disruption, and longevity (post construction cost, schedule and disruption), as well as combined performance. However, as previously noted, only performance through construction has been focused on for now.

Table B-1. Project Cost Estimate (through construction only)

Quantity	Unit of Measure	Unit cost	Description of Work Items	Cost (2009 $)
			CONSTRUCTION	
			PREPARATION	
21	Acre	$4,800.00	Clearing and Grubbing	$99,360
26,397	S.Y.	$8.40	Removing Cement Conc. Pavement	$221,735
26,397	S.Y.	$4.80	Removing Asphalt Conc. Pavement	$126,706
			GRADING	
33,393	C.Y.	$9.60	Roadway Excavation Incl. Haul	$320,573
27,960	C.Y.	$4.20	Common Borrow incl. Haul	$117,432
3,107	C.Y.	$14.40	Gravel Borrow Incl. Haul	$44,741
31,067	C.Y.	$1.20	Embankment Compaction	$37,280
			DRAINAGE	
42	Each	$2,160.00	Grate Inlet Type 1 or 2	$90,720
6	Each	$3,600.00	Drop Inlet Type 1	$21,600
21,120	L.F.	$78.00	Plain St. Culv. Pipe 0.109 In. Thick 36 In. Diam.	$1,647,360
50	L.F.	$1,800.00	St. Stru. Pipe Arch 8 Gauge 20 Ft. 0 In. Span	$89,100
			STRUCTURE	
3,972	S.F.	$145.00	Bridge No. (easy bridge)	$575,940
			SURFACING	
27,047	Ton	$12.00	Crushed Surfacing Base Course	$324,564
			CEMENT CONC. PAVEMENT	
16,696	C.Y.	$110.00	Cement Conc. Pavement	$1,836,560
882	S.Y.	$146.00	Bridge Approach Slab	$128,772
			ASPHALT CONCRETE PAVEMENT	
1,100	Ton	$36.00	Miscellaneous Asphalt Conc. Pavement	$39,600
			EROSION CONTROL AND PLANTING	
2	Acre	$2,400.00	Seeding, Fertilizing and Mulching	$4,800
1	EST.	$85,000.00	Temporary Water Pollution/Erosion Control	$85,000
1,564	C.Y.	$13.20	Topsoil Type B	$20,645
1	EST.	$150,000.00	Miscellaneous Landscaping	
			TRAFFIC	
15,840	L.F.	$120.00	Special Conc. Barrier Type 5	$1,900,800
8	Each	$14,400.00	Permanent Impact Attenuator	$115,200
214,000	L.F.	$0.12	Paint Line	$25,680
1	L.S.	$24,000.00	Permanent Signing	$24,000
			OTHER ITEMS	
4,000	L.F.	$18.00	Temporary Barrier Glare Screen	$72,000
1	EST.	$12,000.00	Roadside Cleanup	$12,000
1	EST.	$6,000.00	Trimming and Cleanup	$6,000
			CONSTRUCTION SUBTOTAL "A" (before Mob, Traffic Control and Other Misc. Items)	$7,988,167
1	L.S.	$399,408.36	Mobilization	$399,408
1	L.S.	$587,130.29	Traffic Control (at 7% of subtotal A + Mob)	$587,130
1	EST.	07	Other Miscellaneous Items (12% of subtotal A + Mob)	$1,006,509
			CONSTRUCTION SUBTOTAL "B" (including Mob, Traffic Control and Other Misc. Items)	$9,981,215
			DESIGN-BUILDER DESIGN FEES (10% of "B")	$998,121
			DESIGN-BUILD CONSTRUCTION TOTAL "C"	$10,979,336
			CONSTRUCTION ADMINSTRATION (8% of "C")	$878,347
			AGENCY DESIGN, ENV, PERMITTING, AND PROCUREMENT (10% of "C" + C. Admin) (includes previous costs of $200,000)	$1,185,768
			RIGHT OF WAY	$2,000,000
			UTILITY RELOCATIONS	$1,000,000
			PROJECT SUBTOTAL "D" (Before Contingency)	$16,043,452

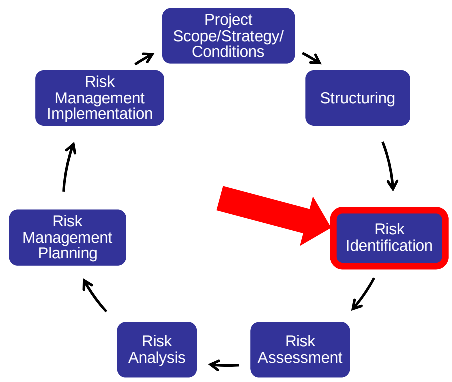
Table B-2. Project Disruption Estimate (including post-construction)

Activity	Duration of Activity (months)	% of Activity Duration Affected	People Affected/ Day	Delay/ person	Disruption (million-hours)
Utilities	12	10%	10,000	½ hr	0.2
Construction	16	20%	10,000	½ hr	0.5
Operations	600	1%	15,000	½ hr	1.4
Replacement	24	10%	20,000	½ hr	0.7

Table B-3. Base Project Performance (from template – see Attachment I; see Figure 2-1 for project flowchart; through construction only)

SUMMARY					
Project Phase	**Total CY Cost ($M)**	**Total YOE Cost ($M)**	**Duration (months)**	**Early Start**	**Early Finish**
Planning		0.00	0	12/1/2009	12/1/2009
Scoping		0.00	0	12/1/2009	12/1/2009
Prelim Design/Environmental Process	1.19	1.21	12	12/1/2009	11/30/2010
Environmental Permits		0.00	6	11/30/2010	6/1/2011
ROW/Util/RR	3.00	3.14	12	11/30/2010	11/30/2011
Final Design		0.00	6	6/1/2011	11/30/2011
Procurement		0.00	6	11/30/2010	6/1/2011
Construction	11.85	12.67	16	7/1/2011	10/30/2012
Operations & Maintenance	0.00	0.00	600	10/30/2012	10/30/2062
Replacement	0.00	0.00	0		
Base Cost (YOE $M)	17.02	(through Operations, Maintenance, & Replacement)			
Base Construction Completion Date	10/30/2012				
Months to Construction Completion	35.00				
Base Disruption ($M)	18.70	(through Operations, Maintenance, & Replacement)			

Module 5:
Risk Identification



5-1

Risk Identification

- **Learning Outcomes**
- Risk Identification
  - Risk, Uncertainty and Risk Register
  - Methods and Process
- QDOT Case Study
- Summary

5-2

Learning Outcomes

- Define risk and opportunity
- Define risk register
- Identify, describe, categorize, and document risks and opportunities that could impact the project

Risk Identification

- Learning Outcomes
- **Risk Identification**
  - **Risk, Uncertainty and Risk Register**
  - **Methods and Process**
- QDOT Case Study
- Summary

Definition of Risk

- Events that *might* occur, which are outside of base assumptions and could change "base" project performance
- Risk has a negative impact (problem)
- Opportunity has a positive impact (improvement)

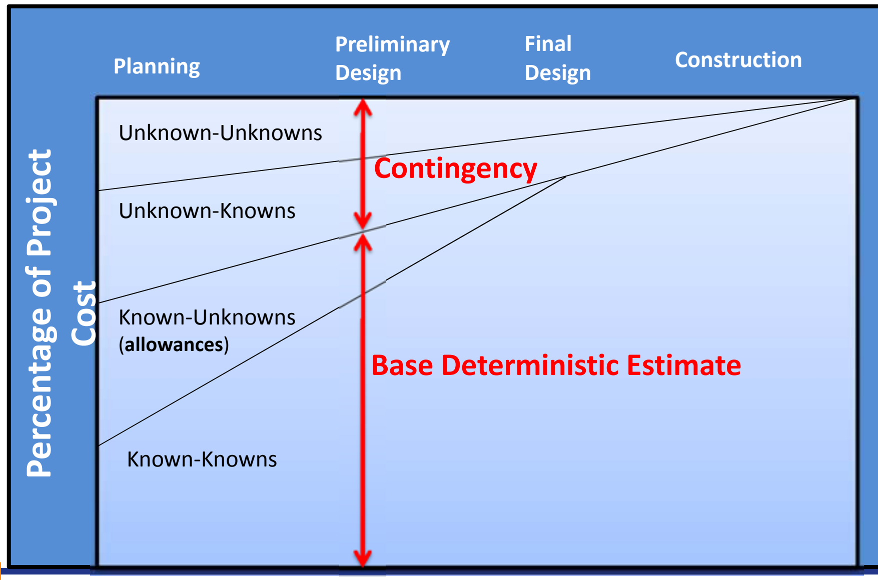
5-5

Describing Uncertainty

"We know it is going to happen" **Known Knowns**	"We expect it to happen, but do not have enough information to quantify it yet." **Known Unknowns** (**ALLOWANCES**)
Unknown Knowns (RISK REGISTER/CONTINGENCY) *"It might happen, but at least we know about it"*	**Unknown Unknowns** *"We didn't see that coming!"*

5-6

Describing Uncertainty



Describing Allowances

- Base Estimate
  - Deterministic
  - Allowances
  - Allowance for Changes during Construction
- Risk Register
  - Contingency removed and turned into Risk Events (Threats and Opportunities)

5-8

Risk Register

- Comprehensive and non-overlapping list of risks and opportunities (includes the following)
  - Risk Identification (Module 5)
  - Risk Assessment (Module 6)
  - Risk Management Planning (Module 7)

5-9

Risk Description

- Nature of issue/event
- Possible causes and thus likelihood
- Possible impacts
- Any relationships with other issues

5-10

Risk Description

Risk Identification (Brainstorming)

Item#	Risk or Opportunity (add rows as needed	Activity[1] (Circle One)	Description (possible non-"base" scenario(s) – causes and consequences)
EXAMPLE		Note: [1] Project activity when risk is most likely to occur, and after which it is very unlikely to occur.	
100	Landowner(s) unwilling to sell at US55-SH111 junction	Planning Scoping Prelim Design Environ. Proc. ROW/Util/RR. Final Design Procurement Construction Operations Replacement Funding	Additional right-of way needed for US555-SH111 junction, as currently designed. However, current owner of needed property might be unwilling to sell at price offered by DOT, so that has to proceed with condemnation, with some additional admin. cost but especially delay to ROW.
		Planning Scoping Prelim Design Environ. Proc. ROW/Util/RR. Final Design Procurement Construction Operations Replacement Funding	

5-11

Risk Identification Methods

- Custom-developed for each project
  - Individuals vs. group
  - Project team and/or independent experts
  - Facilitated (interview/workshop) or not
  - Consensus (implicit/explicit) or not
- Checklist, based on past projects
  - Guide (Appendix D-1 and D-2)

5-12

Risk Identification Process

Steps 1 and 2: Review project information and identify:

- Existing concerns of project team
- Existing concerns of project reviewers
- Issues identified while defining "base" project

Use:

- Judgment and experience from other projects
- Evaluation of project scope, assumptions, conditions, delivery strategy

5-13

Risk Identification Process

- Step 3: Use Risk checklists (Appendices D-1 and D-2) and databases
- Step 4: Categorize identified risks:
  - Organize list by project phase according to where the impact will occur
  - Comprehensive and non-overlapping set
  - Appropriate level of detail
  - Template follows major project activities (flowchart) so category represents when risk can (and cannot) occur

5-14

Risk Identification

- Learning Outcomes
- Risk Identification
  - – Risk, Contingency and Risk Register
  - – Methods and Process
- **QDOT Case Study**
- Summary

5-15

QDOT Case Study for Risk ID

Part A: Risk Identification in groups of 4-5 people:

- Select facilitator
- Review project information (Attachments A and B)
- Identify (via brainstorming) additional risks in assigned categories and record on flipchart
- Review risks by category, and then if necessary edit/add to make each category comprehensive & non-overlapping (consult checklists Appendices D1 and D2 in the back of Module 5, after brainstorming)
- Share results with participants (flipcharts)

Part B: In groups of two people (one laptop/group):

- Document risk identification using Risk template

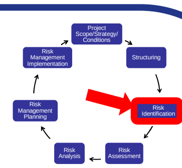
5-16

Risk Identification

- Learning Outcomes
- Risk Identification
  - Risk, Contingency and Risk Register
  - Methods and Process
- QDOT Case Study
- **Summary**

5-17

Summary



- Identify, describe, categorize, consolidate, and document in provided template:
  - Comprehensive and non-overlapping set of risks and opportunities
  - No assessment or screening yet (all possible issues)
  - Relative to project base
- Use Project team and/or independent experts
  - Think broadly (as group)

5-18

Questions?

goSHRP2@dot.gov

SHRP2 SOLUTIONS

Save lives. Save money. Save time.

5-19

Risk Register

Item	Risk or Opportunity (by category) (add lines with labels as needed)	Initial Item#	Description (possible non-"base" scenario(s) – causes and consequences)
PL	***Planning Risks***		
PL1			
PL2			
PL3			
SC	***Scoping Risks***		
SC1			
SC2			
SC3			
SC4			
PD	***Prelim Design / Enviro Process Risks***		
PD1			
PD2			
PD3			
PD4			
PD5			
PD6			
EP	***Environmental Permits Risks***		
EP1			
EP2			
EP3			
RU	***ROW/Utility/RR/etc. Risks***		
RU1			
RU2			
RU3			
RU4			
FD	***Final Design Risks***		
FD1			
FD2			
FD3			
FD4			

Risk Register

Item	Risk or Opportunity (by category) (add lines with labels as needed)	Initial Item#	Description (possible non-"base" scenario(s) – causes and consequences)
CP	***Procurement Risks***		
CP1			
CP2			
CP3			
CP4			
CP5			
CN	***Construction Risks***		
CN1			
CN2			
CN3			
CN4			
CN5			
CN6			
CN7			
CN8			
CN9			
CN10			
OM	***Operations Risks***		
OM1			
OM2			
OM3			
RP	***Replacement Risks***		
RP1			
RP2			
RP3			
F1	***Design Funding Risks***		
F1-1			
F1-2			
F2	***ROW/UTL/RR Funding Risks***		

Risk Register

Item	Risk or Opportunity (by category) (add lines with labels as needed)	Initial Item#	Description (possible non-“base” scenario(s) – causes and consequences)
F2-1			
F2-2			
F3	***Construction Funding Risks***		
F3-1			
F3-2			

Note: Transfer risks from Risk ID Form (brainstorming) to appropriate category. Edit to be comprehensive/non-overlapping. See checklists.

Risk Identification (Brainstorming)

Item#	Risk or Opportunity (add rows as needed	Activity[1] (Circle One)	Description (possible non-"base" scenario(s) – causes and consequences)
EXAMPLE Note: [1] Project activity when risk is most likely to occur, and after which it is very unlikely to occur. [2] Pr Dsn/Env Pr = preliminary design and environmental process			
100	Landowner(s) unwilling to sell parcel <xxx>	Planning Scoping Pr Dsn/Env Pr[2] Enviro Permits ROW/Util/RR Final Design Procurement Construction Operations Replacement Funding	Additional right-of-way needed for project, as currently designed. However, current owner of needed property might be unwilling to sell at price offered by DOT, so that have to proceed with condemnation, with some additional admin cost but especially delay to ROW process.
		Planning Scoping Pr Dsn/Env Pr[2] Enviro Permits ROW/Util/RR Final Design Procurement Construction Operations Replacement Funding	
		Planning Scoping Pr Dsn/Env Pr[2] Enviro Permits ROW/Util/RR Final Design Procurement Construction Operations Replacement Funding	
		Planning Scoping Pr Dsn/Env Pr[2] Enviro Permits ROW/Util/RR Final Design Procurement Construction Operations Replacement Funding	
		Planning Scoping Pr Dsn/Env Pr[2] Enviro Permits ROW/Util/RR Final Design Procurement Construction Operations Replacement	

Risk Identification (Brainstorming)

Item#	Risk or Opportunity (add rows as needed	Activity[1] (Circle One)	Description (possible non-"base" scenario(s) – causes and consequences)
EXAMPLE Note: [1] Project activity when risk is most likely to occur, and after which it is very unlikely to occur. [2] Pr Dsn/Env Pr = preliminary design and environmental process			
100	Landowner(s) unwilling to sell parcel <xxx>	Planning Scoping Pr Dsn/Env Pr[2] Enviro Permits ROW/Util/RR Final Design Procurement Construction Operations Replacement Funding	Additional right-of-way needed for project, as currently designed. However, current owner of needed property might be unwilling to sell at price offered by DOT, so that have to proceed with condemnation, with some additional admin cost but especially delay to ROW process.
		Funding	
		Planning Scoping Pr Dsn/Env Pr[2] Enviro Permits ROW/Util/RR Final Design Procurement Construction Operations Replacement Funding	
		Planning Scoping Pr Dsn/Env Pr[2] Enviro Permits ROW/Util/RR Final Design Procurement Construction Operations Replacement Funding	
		Planning Scoping Pr Dsn/Env Pr[2] Enviro Permits ROW/Util/RR Final Design Procurement Construction Operations Replacement Funding	
		Planning Scoping Pr Dsn/Env Pr[2] Enviro Permits ROW/Util/RR Final Design Procurement Construction	

Risk Identification (Brainstorming)

Item#	Risk or Opportunity (add rows as needed	Activity[1] (Circle One)	Description (possible non-“base” scenario(s) – causes and consequences)
EXAMPLE	Note: [1] Project activity when risk is most likely to occur, and after which it is very unlikely to occur.		[2] Pr Dsn/Env Pr = preliminary design and environmental process
100	Landowner(s) unwilling to sell parcel <xxx>	Planning Scoping Pr Dsn/Env Pr[2] Enviro Permits ROW/Util/RR Final Design Procurement Construction Operations Replacement Funding	Additional right-of-way needed for project, as currently designed. However, current owner of needed property might be unwilling to sell at price offered by DOT, so that have to proceed with condemnation, with some additional admin cost but especially delay to ROW process.
		Operations Replacement Funding	

Appendix D. Rapid Renewal Risk Categories and Risk Management Action Categories

Appendix D consists of three sections:

- Appendix D.1 Risk Checklist for Traditional Transportation Projects
- Appendix D.2 Summary Risk Checklist for Rapid Renewal Projects
- Appendix D.3 Rapid Renewal Risk Categories and Potential Risk Management Actions by Project Phase

<this page is intentionally blank>

Appendix D.1. Risk Checklist for Traditional Transportation Projects

As shown, the items on this list do not form a formal risk register (i.e., this is not a comprehensive list of items for any particular project, and the listed items are *not* non-overlapping by intention). The list is only intended to serve as a supplemental "checklist" to identify items missed during brainstorming. Identified items then need to be redefined/recast to ensure a comprehensive, non-overlapping set of events in the risk register (adequately considering significant relationships (correlation, dependency) among items in the list, if any).

Some items shown are really "base uncertainty" (i.e., uncertainty within the base project/estimate assumptions), while the remainder are truly risk and opportunity events (i.e., uncertain conditions and events outside the base assumptions).

When identifying and quantifying risk, consider the issue of ownership/allocation (i.e., it's a risk to whom? And who pays?), impacts of insurance in capping costs, influence of "below-the-line" markups, correlation between cost and time impacts, etc.

Uncertainty in "Soft" Costs and / or Schedule (other than identified through other items, and *excluding additional costs that result from project delays*, which are accumulated directly and additionally through simulation). Fundamental question: Is the base estimate for each in terms of a percentage of construction cost? or a detailed line-item estimate?

- Design completion
- PS&E completion
- Administration costs (owner)
- Oversight costs (regulator)
- Construction management and construction inspection (CEI)
- Project management
- Design support during construction / construction engineering
- Mobilization
- Sales tax
- Financing, including interest costs
- Insurance
- Surety capacity and bonding
- Annual inflation rates (construction, right-of-way, engineering, other)
- Stipends
- Extended overheads from project delays (if not captured separately)

Contracting, Procurement, and Project Delivery

- Project delivery method (D/B, D/B/B, PPP), including uncertainty in ultimate method, and new or unique method to owner
- Single vs. multiple contracts (if not captured under market conditions)
- Construction market conditions (contractor pricing strategy/markup; cyclic market, and location within cycle at time of bid; number of viable bidders), including the potential for delay to the procurement process and/or re-bidding
- Significant increase in material, labor, or equipment costs (beyond what's included in inflation rates and market conditions)
- Delays procuring critical materials, labor, or specialized equipment
- Bid protests
- Claims related to clarity of bid and contract documents
- Errors and omissions
- Other issues related to unclear contract documents (identified during either procurement or later during construction)
- Other delays to contract procurement process (e.g., bonding and insurance issues)
- Owner approach to specifications (e.g., prescriptive versus performance-based)
- Incomplete or vague specifications

- Contractor non-performance (inefficiency if the impacts are not due to or captured by other risk items; default; bankruptcy)

Construction and Constructability (see also Geotech and Structures; there is some overlap in these two lists)

- Additional pavement resurfacing
- Additional geometry re-alignment
- Uncertainty in construction unit costs (e.g., earthwork)
- Uncertainty in construction quantities (e.g., bridges, walls)
- Inadequate staging areas identified for construction
- Dewatering issues during construction
- Issues related to tunnel construction procedures (see also tunneling under Geotech)
- Issues related to other construction procedures
- Uncertainty in planned construction sequencing / staging / phasing / construction duration
- Planned construction phasing doesn't work (need new plan)
- Maintenance of traffic (MOT) / work zone traffic control (WZTC) issues
    - Labor for assumed plan if plan is adequate
    - Proposed plan is not adequate
    - Issues related to detours
- Difficult or multiple contractor interfaces
- Uncertainty in structure demolition sequence and method
- Force Majeure during construction (acts of nature that impact construction, like earthquake, tornado, etc.)
- Safety issues (personnel, adjoining structures)
- Material reuse, removal, restoration
- Condition of existing structures (repair required?)
- Accidents/incidents during construction (traffic/collapse/crane toppling/slope failure/vandalism)
- Critical equipment failure
- Excessive scour or flooding
- New or unproven systems, processes, or materials
- Marine-construction issues
- Other difficult or specialized construction issues
- Tie-ins with existing facilities/roadways/structures/local access
- Failure prior to replacement (e.g., bridges)
- Additional temporary erosion and sediment control (TESC) costs
- Railroad conflicts (anticipated or unanticipated)
- Utility conflicts (anticipated or unanticipated)
- Work-window restrictions (e.g., fish windows, weather shut-down windows)
- Other third-party delays during construction

Design

- Uncertainty in, or risk or opportunity related to, the "base" design elements (e.g., due to early design, project definition, or development), including type, size, and location (TS&L) and unit prices and quantities. Consider related (i.e., correlated or dependent) impacts to design, ROW, environmental documentation, permitting, utilities, and construction. Consider relationships to other issues in this list (conditionality/correlation). Example items include:
    - horizontal alignment (e.g., geometry / grade)
    - vertical alignment (e.g., underground vs. surface vs. aerial)
    - bridges (superstructure and substructure)
    - retaining walls
    - earthwork
    - noise walls
    - other structures
    - stormwater collection and treatment
    - paving
    - right-of-way (e.g., full vs. partial takes; uncertain parcels/quantities)

  - maintenance of traffic / traffic control
  - Traffic Demand Management (TDM) / Intelligent Traffic Systems (ITS)
  - construction staging/phasing
  - electrical (systems, signals, illumination)
  - mechanical
- Design errors and omissions or errors in plans/specs/estimates (discovered during construction)
- Urban design and construction issues
- Changes in design standards (e.g., increased seismic criteria for structures)
- Design deviations (e.g., design speeds, vertical clearances, turn radii)
- Access deviations (e.g., FHWA)
- Additional aesthetics / context-sensitive solutions (CSS)
- Allowances for miscellaneous items (known pay items not yet itemized in the estimate)
- Floodplain issues

Environmental

- Uncertainty in appropriate environmental documentation (e.g., DCE vs. EA vs. EIS), and all the related consequential events (e.g., change in design, ROW, scope, and construction costs)
- Challenge to environmental documentation (e.g., resulting in delay in ROD)
- Delay in review and/or approval of environmental documentation
- Supplemental environmental documentation or re-evaluation required
- Challenge to Early-Action Mitigation Plan (Wetlands, Floodplain/Habitat)
- Additional habitat mitigation required, on- or off-site (e.g., wetlands, fish ladders, meandering; connectivity)
- Uncertain wetland mitigation (e.g., uncertain impacts, uncertain type of mitigation (replacement, enhancement, banking); different replacement ratio than assumed)
- Difficulty identifying and/or acquiring suitable wetland-mitigation site (including collecting required growing-season data)
- Biological Assessment consultation issues / delay
- New species listings (ESA)
- Encounter unanticipated listed species during construction
- Uncertain stormwater treatment standards or quantities
- Uncertain stormwater discharge criteria (e.g., Receiving body exemptions)
- Uncertain groundwater treatment standards or quantities
- Encounter unanticipated contaminated or hazardous materials (and possibly extent of liability for remediation)
- Encounter unanticipated contaminated groundwater (and possibly extent of liability for remediation)
- Additional noise mitigation required
- Additional view mitigation required
- Unanticipated Section 106 issues (archaeological, cultural, or historical finds) encountered during design or construction
- Known Section 106 issues different than anticipated
- Unanticipated 4(f) issues
- Known 4(f) issues different than anticipated
- Other Regulatory Issues (EIS, NEPA, etc.)

External Influences and Management (e.g., Political, Regulatory, Municipalities, Economic)

- Difficulty obtaining other agency approvals/agreements (higher-level, municipalities)
- Conflicts with other projects (municipalities, counties, state)
- Other predecessor projects not completed on time (delay current project)
- Coordination with other entities (e.g., Railroads)
- Coordination between multiple contractors on this project
- Force Majeure during design (e.g., earthquake causes existing facility to fail, requiring accelerated design/construction of new facility)
- Public opposition
- Political opposition

- Funding shortfall (and related delay or increased financing cost)
- Funding delay
- Legal challenges (other than environmental)
- Intergovernmental agreements and jurisdiction
- Labor issues (contract negotiations/strike)
- Tribal issues (e.g., fishing rights, TERO employment, etc.)
- Program management / executive oversight issues
- Project management issues / workload management
- Revenue issues (ridership; regulations/policies)
- Cash flow constraints
- Other significant constraints/milestones/"promises" to be met

Geotechnical and Structural

- Uncertainty in bridge or culvert design (including type/size/location (TS&L) – foundations and superstructure)
- Difficult bridge construction (e.g., transportation or erection of large components; other specialty construction; groundwater, adverse ground conditions; obstructions; scour; other foundation problems)
- Uncertainty in retaining wall design (including type, length, height – foundations and superstructure)
- Difficult retaining-wall construction (e.g., groundwater, adverse ground conditions; obstructions; other foundation problems)
- Slope stability issues – natural, man-made (cuts, embankments), etc.
- Liquefaction design issues
- Uncertainty in seismic design criteria
- Uncertainty in ground improvement design (e.g., what type, how much is required)
- Uncertainty in ground improvement performance (i.e., construction – need additional or different type of improvement)
- Damage to nearby structures during construction or as result of construction
- Tunneling-specific issues
    - Uncertain or early design (including uncertainty in tunneling method, lining, etc.)
    - TBM problems (e.g., TBM operator issues / inexperience; machine procurement; machine assembly, disassembly, and recover; machine maintenance; power-supply problems; drive rate/productivity (various causes, including obstructions or other poor ground conditions); drive misalignment; other problems)
    - Liner problems (e.g., damaged liner segments; bad gasket/seal resulting in leakage)
    - Problems with shaft or emergency exit construction
    - Problems with cross-passage excavation
    - Other tunnel construction problems
- Compatibility of new structures when placed adjacent to existing structures
- Other general geotechnical risk

Operations and Maintenance

- Uncertain annual costs for typical maintenance
- Additional resurfacing or re-decking cycle(s) required
- Additional significant (unplanned) maintenance required
- Uncertain O&M period (e.g., for P3 concessions)

Permitting

- Difficulty obtaining permit approval (by permit type; e.g., 401, 404, NPDES, USCG, shoreline) – manpower issues; incomplete or inadequate permit applications; or simple disagreement by approving agencies
- Uncertain permit requirements (current and in the future)
- Challenges to permits once issued (e.g., shoreline, 401, 404)
- Air quality permitting issues
- Non-compliance with permits (environmental or construction)

Right-of-Way / Real Estate

- Global right-of-way (ROW) problems (for widening, drainage, pipelines, detention, staging, etc.)
- Additional right-of-way required (e.g., plans change; inaccurate early estimates)
- Difficult or additional condemnation (either globally or for particular parcels)
- Additional relocation required (either globally or for particular parcels – business vs. residential)
- Additional demolition required (including unanticipated remediation) (either globally or for particular parcels)
- Accelerating pace of development in project corridor
- Changes in land use / demographics in project corridor
- Manpower shortages
- Process delays (e.g., ROW plan development by team; plan approval process)
- Planned ROW donations do not occur, or opportunity for additional donations
- Difficulty obtaining rights-of-entry
- Railroad ROW Problems
- Issues related to required easements (surface, subsurface)
- Other ROW issues

Scope Issues (other than identified through other items elsewhere in this list, such as design)

- Additional capacity required (e.g., lanes)
- Additional interchanges required (system-to-system or service)
- Additional local improvements required (e.g., additional paving or signals on local connections)
- Additional transit facility, park-and-ride, etc. required
- Other additional structures required (e.g., wildlife crossings)
- Scope reduction opportunity / Value Engineering
- Replace structures instead of retrofit existing (or vice-versa)
- Tolling facilities
- Managed lanes
- Note on scope changes: scope changes can occur during design and/or construction, and can be due to:
  - Incomplete design
  - Stakeholder influences leading to additional scope (e.g., aesthetics; political pressure)
  - Errors in design
  - Construction problems
  - Regulatory changes

Systems

- Software problems (technical, labor)
- Electrical-system problems (technical, labor)
- Mechanical-system problems (technical, labor)
- Problems with station finishes (technical, labor)
- Track-installation problems (technical, labor)
- Problems related to systems integration and testing

Traffic and Access Issues

- Uncertainty in traffic management costs (ITS, TDM)
- Access to site during construction
- Business or economic disruption mitigation

Utilities Issues

- Delay in completing utility agreements (for example, due to: disagreement over responsibility to move, disagreement over cost-sharing; delay in reviews and approvals by utility)
- Late changes to design delays utility planning (e.g., have to re-do utility design)
- Utility relocations to be completed by others (utility companies, municipalities) are not completed on time
- Encounter unexpected utilities during construction

- Damage utilities during construction (known or unknown)
- Utility integration with project and/or utility betterments not as planned
- Cost sharing with utilities not as planned

Vehicles

- Uncertainty in required number and/or type of vehicles
- Uncertainty in contracted price for vehicles (may include uncertainty in number/type of vehicles)
- Delay in vehicle delivery
- Cost increase due to change orders (for various reasons, perhaps detailed separately; separate from uncertainty in contract price)

Appendix D.2. Summary Risk Checklist for Rapid Renewal Projects

The lists below summarize *categories* or types of rapid renewal risks by project phase. The lists do not attempt to capture specific risks related to rapid renewal. Use these lists of risk categories as a quick 'check' to make sure no major types of risks were missed during initial risk brainstorming.

Because the lists below only address *categories* of risks, they do not constitute a proper risk register. To develop a risk register, the DOT must identify a comprehensive, non-overlapping set of *individual* (i.e., specific) risks and opportunities for the particular project being considered. More detail is provided in Appendix D.3 for each of the entries below.

Finally, *the DOT should remember to consider risks and opportunities for all aspects of a project* – not just for the rapid renewal elements covered specifically in this Guide.

Planning

- Inaccurate planning assumptions and projections
- Resources not available from all disciplines for advanced planning
- Advanced planning for rapid renewal projects not coordinated with transportation network
- Uncompleted or unfeasible rapid renewal project erode public trust
- Planning partners do not have resources to partner in advancing rapid renewal projects

Project Scoping (including project delivery and funding / financing)

- Project contains unrealistic scope considering budget and political landscape
- Master planning / integrated development process is inefficient or poorly implemented
- Owner not capable of managing the delivery method
- Delivery method not appropriate for the project
- Procurement protest pre-award
- Dispute post-award
- Market cannot support to selected delivery method / method restricts competition
- Other cost and/or schedule premium resulting from delivery method
- Cost premiums resulting from innovative payment structure
- Insufficient market interest in innovative payment processes to create competition
- Poor market conditions make securing financing difficult
- Enabling legislation not in place to allow alternative financing
- Changes in legislation before financial close (e.g., tolling, competing facilities) jeopardize alternative financing
- Other delay in funding process
- Actual revenues significantly less than anticipated (O&M)
- Surety market cannot support project's bond requirements
- Bonding capability of contractor(s) not adequate
- Lack of payment bond results in subcontractor protests or claims
- Contractor defaults

Environmental Process and Permits

- Different type of environmental documentation required
- Additional documentation required (but not a change in document type)
- Other delay to completion of environmental process related to attempted acceleration
- Approval / signatory organizations cannot accommodate streamlined processing / approval
- Review and approval process takes longer than anticipated for other reasons
- Challenge to environmental documentation once determination has been issued
- Development of permit application takes longer than anticipated
- Delay in permit review or approval
- Unanticipated or additional permits required
- Challenge to permits once issued
- Streamlined mitigation effort won't work (management issue)
- Streamlined mitigation effort won't work (technical issue)

Design and Construction (General Principles)

- Key design decisions are delayed
- Other key project-related decisions are delayed or changed
- Stakeholders not able (or willing) to support accelerated design process
- Encounter unanticipated changes in design standards
- Standardized designs not available or suitable
- Delay in approval of design exceptions, or denial of design exceptions
- Staffing for accelerated design not available
- Owning agency not staffed or structured for streamlined approvals
- Stakeholders unable or unwilling to accommodate streamlined approvals
- Delays to other activities delay the design's approval
- Mistakes in the design delay the design's approval
- Constructability review not allowed (policy)
- Constructability review not successful
- Constructability review successful, but leads to significant changes in design

Design and Construction (by Discipline)

- *Consider each of the following categories of rapid renewal risks and opportunities separately for each design discipline* and/or major project component (e.g., structures, geotechnical and earthwork, drainage and stormwater management, roadway, pavement, and ITS)
  - Innovative designs
    - Innovative and/or long-life designs not the right solution for the project
    - Innovative designs can work technically, but require design exceptions or have difficult permitting requirements
  - Alternative or long-life materials
    - Candidate alternative and/or long-life materials won't work (technical issues identified during design)
    - Delay in procuring candidate alternative and/or long-life materials
  - Rehabilitation
    - Rehabilitation not the best option (identified during design)
    - Problems with rehabilitation during construction
  - Pre-fabrication
    - Candidate pre-fabrication technique won't work (technical issues identified during design)
    - Delay in procuring pre-fabricated elements
    - Problems with pre-fabricated elements during construction
  - Rapid-replacement technologies
    - Candidate rapid-placement technique won't work (technical issues identified during design)
    - Delay in procuring rapid-replacement equipment and/or specialized labor
    - Problems with rapid-replacement technique during construction
- Maintenance of Traffic – full or directional closures
  - Planned closures and related detour routes are not allowed (political or management issue)
  - Planned closures and routes won't work (technical issue identified during design)
  - Planned closures and routes will work but are not most efficient (better plan identified later during design)
  - Implemented closure plan doesn't work (problem identified during construction)

Right-of-Way, Utilities, and Railroad

- Right-of-Way (ROW)
  - Late changes to the design cause delay in ROW planning
  - ROW plans not completed as planned for other reasons
  - Funding for accelerated or advance ROW acquisition delayed or reduced

    - Problems procuring critical (high-priority) parcels, such as
        - Challenge to possession-and-use
        - Condemnation required
        - Difficulties relocating tenants
        - Unanticipated contamination or utilities discovered
        - Additional demolition required
    - Delay to ROW certification (agency process delay)
- Utilities
    - Late changes to the design cause delay in utility planning
    - Utility agreements not reached as planned (from causes other than late design changes)
    - Encounter and/or damage utility during construction (if the owner's contractor performs the work)
    - Third party does not complete relocation as planned (if third party performs the work)
- Railroad
    - Late changes to the design cause delay in railroad planning
    - Railroad agreements not reached as planned (from causes other than late design changes)
    - Damage railroad facility during construction (if owner's contractor performs the work)
    - Railroad does not complete agreed railroad-related work as planned (if railroad performs the work)

Procurement (including Contracting Strategy)

- Litigation initiated by an interested party challenging the propriety of the alternative procurement process
- Public concern (and political pressure) resulting from the use of alternative procurement processes that heavily weight non-price factors
- Public reaction to alternative procurements that trade-off early accelerated completion with full road closures
- Limited competition arising from projects perceived as being created for large contractors
- Other problems procuring contract (e.g., bid protest, unclear documents, contractor default)
- Litigation initiated by an interested party challenging the propriety of the alternative contract packaging
- Public concern (and political pressure) resulting from the use of alternative contract packaging
- Expending funds in advance of full procurement (for advance procurement)

Operations and Maintenance (O&M)

- Required O&M effort greater than planned (more frequent, more extensive, or both)
- O&M contractor does not perform per contract requirements

Replacement

- Replacement required sooner than planned
- Replacement facility does not perform as intended

<this page is intentionally blank>

Appendix D.3. Rapid Renewal Risk Categories and Potential Risk Management Actions by Project Phase

Appendix D.3 provides substantially more detail for each of the items identified in Appendix D.2. For each project phase, the following is provided in a separate table:

- General rapid renewal strategies that might be employed during that project phase.
- For each rapid renewal strategy, the table lists categories, or types, of risks and opportunities that might result from following a particular rapid renewal strategy. The categories of risks and opportunities were identified as "risks to the owner" and to the owner's rapid renewal objectives for the project (i.e., minimizing cost, minimizing schedule, minimizing disruption, and maximizing longevity).
- Potential risk-management actions to address the various categories of risks and opportunities.

The tables in Appendix D.3 therefore contain more background and detail on each risk category, including the corresponding rapid renewal strategy and example risks and risk management actions. The authors encourage DOTs to review the more-detailed documentation in Appendix D.3 to develop a better understanding for how each risk category was developed and what each category means.

The tables for each project phase include:

- Table D-1. Planning
- Table D-2. Project Scoping (including project delivery and funding / financing)
- Table D-3. Environmental Process and Permits
- Table D-4a. Design and Construction (General Principles)
- Table D-4b through D-4g. Design and Construction (by Discipline, such as Structures, Geotechnical, etc.)
    - Table D-4b. Structures
    - Table D-4c. Geotechnical and Earthwork
    - Table D-4d. Drainage and Stormwater Management
    - Table D-4e. Roadway, Geometrics, and ITS
    - Table D-4f. Pavement
    - Table D-4g. Maintenance of Traffic (MoT)
- Table D-5a. Right of Way
- Table D-5b. Utilities
- Table D-5c. Railroad
- Table D-6. Procurement (including Contracting Strategy)
- Table D-7. Operations and Maintenance
- Table D-8. Replacement

Notes for all Tables:

1. The Risk Categories are not intended to be specific risks, only general categories of potential issues that serve as prompts for identifying specific issues. Therefore, the listed categories cannot be taken together to form a proper risk register (i.e., they are not a comprehensive, non-overlapping list of risks and opportunities).
2. The Potential Risk-Management Actions are assumed to not already be part of the project plan. All actions should cost-effectively improve performance measures. The actions are not necessarily presented as one-to-one correspondence with risk categories because some actions might address more than one risk category.

<this page is intentionally blank>

Table D-1. Project Phase: Planning

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
Conduct programmatic / portfolio planning Examples: • Long range requirements, resources, and constraints • Short range requirements, resources, and constraints		The following potential risk-management actions could apply to a number of the risk categories in the column to the left: • Focus internal planning efforts on rapid renewal projects as a priority over traditional projects • Create awareness with planning partners (e.g., metropolitan planning organizations, municipalities, etc.) of rapid renewal projects • Secure public awareness or "buy-in" for rapid renewal project early in planning • Early coordination and buy-in with local businesses that could be affected by closures and detours • Secure additional planning resources to monitor and update rapid renewal project approaches
	Inaccurate planning assumptions and projections Examples: • Inaccurate traffic projections • Inaccurate population growth projections • Intermodal transportation plans not coordinated or inaccurate	
Conduct early coordination – internal Examples: • Develop integrated team (technical disciplines, project development, finance, communications) • Prioritize planning studies on rapid renewal projects		

Table D-1. Project Phase: Planning

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
	Resources not available from all disciplines for advanced planning Examples: • Technical staff not available for research (e.g., right of way, utilities, etc.) • Technical staff not familiar with planning process (e.g., right of way, utilities, etc.)	
	Advanced planning for rapid renewal projects not coordinated with transportation network Examples: • Funding opportunities for alternative transportation modes makes advanced planning obsolete • Advancement of rapid renewal project creates strain on traditional planning areas	
Conduct early coordination – external Examples: • Develop stakeholder awareness • Gather political support • Establish single-point communication • Brand the project • Conduct public outreach / seek additional investment		
	Uncompleted or unfeasible rapid renewal project erode public trust Examples: • Funding for rapid renew project not available as “sold” to the public	

Table D-1. Project Phase: Planning

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
	• Rapid renewal project identified in planning not feasible due to environmental constraints • Public opposition from small stakeholder groups successful in stopping project • Opposition from industry groups (e.g., trucking and freight stakeholder groups)	
	Planning partners do not have resources to partner in advancing rapid renewal projects Examples: • Metropolitan planning organizations do not have staff to advance rapid renewal project and still meet other commitments	

Table D-2. Project Phase: Project Scoping (including project delivery and funding / financing)

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
Conduct early and comprehensive scoping Examples: • Obtain stakeholder input early • Develop and confirm purpose and need early • Develop and test viable alternatives early • Balance scope, budget and political goals of the project	**Project contains unrealistic scope considering budget and political landscape**	The following potential risk-management actions could apply to a number of the risk categories in the column to the left: • Conduct a thorough assessment of how much the agency is willing (or can afford) to spend on the project • Make an early decision on scope that is mandatory vs. discretionary, with due consideration for financing options and political/stakeholder concerns. • Determine plan for implementing what is determined to be discretionary scope • Consider multiple project phasing options early in the process so that the project can be staged
Employ master planning / integrated project development process Examples: • Integrate engineering, environmental analysis, agency coordination, public involvement into collaborative decision-making process	**Master planning / integrated development process is inefficient or poorly implemented**	Examples: • Conduct outreach within the agency to discuss how to best integrate functions • Early retention of any consultants who will be assisting agency's personnel • Consider using outside partnering consultant to assist in coordination efforts
Use innovative project delivery, including: • **Design/Build** • **Design/Build/Finance/ Operate/Maintain** • **CM at-risk** • **Public-Private Partnership (private**		The following potential risk-management actions could apply to a number of the risk categories in the column to the left: • Secure enabling legislation early (applies to many) • Conduct outreach to the state Attorney General (AG) and obtain AG opinions

Table D-2. Project Phase: Project Scoping (including project delivery and funding / financing)

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
equity or debt) Examples: • Ensure authorizing legislation • Ensure agency has experienced staff • Develop project delivery selection methodology		for statutory areas that are unclear or evolving • Conduct broad training programs on alternative project delivery with staff • Utilize FHWA resources for training and education • Secure general engineering consultants with experience in innovative project delivery methods • Conduct outreach to other DOTs that have a history of success in implementing alternative delivery programs
	Owner not capable of managing the delivery method (could lead to delay in contracting; change in delivery method; etc.) For example, caused by: • Untrained internal resources • Management systems not established • Resources not available as needed • Lack of timely dispute resolution (e.g., from unclear documents; lack of experience)	• Implement training programs for all personnel involved in project delivery decisions • Develop programmatic approach for alternative delivery methods with policy statements and general guidelines prior to need for a specific project • Establish a specialized group within the agency to handle rapid renewal projects delivered through alternative project delivery methods • Use staff augmentation contracts to assist agency personnel in implementing the procurement and contracting of the project and assist in training • Develop comprehensive lessons learned from project experiences
	Delivery method not appropriate for the project (could lead to delay in contracting; change in delivery method; etc.).	See above. In addition: • Develop comprehensive process for

Table D-2. Project Phase: Project Scoping (including project delivery and funding / financing)

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
	For example, caused by: • Method conflicts with owner goals • Project risk profile mismatched to delivery method • Stakeholders not aligned • Owner's goals change • No enabling legislation	project delivery selection and establishing project goals, with broad participation from interested agency departments • Integrate project delivery selection with risk registering process • Consider bringing key stakeholders into the training process and project delivery selection process
	Procurement protest pre-award (could lead to delay in contracting; change in delivery method; etc.) For example, caused by: • Insufficient history within owner organization with delivery method • Unfamiliarity of agency with evaluation of non-price factors • Unclear evaluation factors • Inappropriate discussions with proposers • Challenges to the legality of the statute allowing the delivery system	In addition to some of the items above (including training and lessons learned compilation): • Ensure that the team is supported by experienced individuals (internal or consultants) • Outreach to public to determine where the potential statutory challenges may lie • Develop a requirement in the procurement documents for any protests over the process (i.e., legality of the procurement) to be raised early rather than after any shortlist evaluations • Develop a comprehensive process for how communications with proposers will be handled
	Dispute post-award (could lead to delays and price increases) For example, caused by: • Inadequate scope definition • Ambiguous specifications • Overly active involvement of the agency in	In addition to the above: • Consider having a third party peer review of technical scoping documents to assess completeness, accuracy and whether they are overly prescriptive • Consider having a period of time

Table D-2. Project Phase: Project Scoping (including project delivery and funding / financing)

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
	contractor's means and methods	immediately after award for contractor to assess project scope and determine whether there are any material problems with the RFP documents that could not have been determined during the proposal period • Develop an internal process and training for project personnel on how to review submittals
	Market cannot support selected delivery method and/or method restricts competition For example, caused by: • Contractors lack experience • Restrictions by agencies on ability of design professionals to participate on the contractor's team because of conflicts of interest	In addition to the above, particularly relative to legislative solutions and outreach: • Consider having a more liberal conflict of interest policy (see federal model) • Conduct regular meetings with contractor and consulting engineering associations to assess what is needed to obtain sufficient interest
	Other cost and/or schedule premium resulting from delivery method (aside from issues listed separately) For example: • Contractor perception of high risk • Contractor concern over whether the project is "real" given scope appearing to exceed budget	See above; In addition: • Have contracts with reasonable risk allocation • Ensure that the proposers understand that agency is taking steps to be a "good owner" in managing the process
Use innovative contract payment processes Examples: • Milestone construction-related payments • Availability payments for PPP projects		The following potential risk-management actions could apply to a number of the risk categories in the column to the left: • Identify other agencies that have successfully used innovative payment terms • Investigate and implement best

Table D-2. Project Phase: Project Scoping (including project delivery and funding / financing)

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
• Incentives/disincentives • Warranty and O&M payment		practices • Consult with marketplace to evaluate what has worked well and what has not • Establish that contract payment process correlates with behavior changes expected from contracting teams
	Cost premiums resulting from payment structure For example: • Contractor unfamiliarity leads to pricing premiums • Contractor concerns over unreasonable risk (not getting paid)	In addition to the above: • Use outreach process to assess market interest in the alternative approach, particularly for innovative warranty, O&M or availability payments • Create balanced contracts that eliminate major uncertainty for contracting community • Determine financing costs (if any) to be incurred by the contractor in the innovative process • Assess the cost to benefit of using disincentives
	Insufficient market interest in innovative payment processes to create competition	In addition to the above: • Evaluate surety market to assess its concerns over the approach • Conduct regular meetings with contractor and consulting engineering associations to assess what is needed to obtain sufficient interest
Seek alternative financing Examples: • Grant Anticipation Revenue Vehicle (GARVEE) bonds • Generate revenue through user fees (e.g., HOV / HOT		The following potential risk-management actions could apply to a number of the risk categories in the column to the left: • Secure enabling legislation early (applies to many), e.g., related to open road tolling (transponders vs. toll booths) and/or tolling enforcement.

Table D-2. Project Phase: Project Scoping (including project delivery and funding / financing)

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
lanes tolling)		• Retain an outside financial advisor to be integrally involved in the development of the project and financial modeling • Develop realistic revenue projections • Develop realistic scope, cost, schedule requirements • Develop financial terms early, including industry review • Re-package project (e.g., multiple, smaller projects) to improve market conditions • Obtain a detailed traffic and revenue study and financial model that can be used to assess the project and how the marketplace is likely to respond to the preferred financing approach • Assess the cost-to-benefit of using alternative financing, particularly in the event that financial close does not take place in a timely fashion

Table D-2. Project Phase: Project Scoping (including project delivery and funding / financing)

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
	Poor market conditions make securing financing difficult (reduced and/or delayed funding). Examples: • Difficult market • Market collapses • Proceeding on the assumption that there will be sufficient market interest to provide proposals on a revenue-negative project • Miscalculating the amount of agency-funds needed to make the project viable to the financing community	See above
	Enabling legislation not in place to allow alternative financing	In addition to the above: • Work with attorney general's office and state financing department to assess likelihood of passing such legislation • Consider lessons learned from jurisdictions where this has been used • Make early "go/-no-go" decision on project viability without alternative financing
	Changes in legislation before financial close (e.g., tolling, competing facilities) jeopardize alternative financing	• Ensure that RFP documents have mechanisms to address changes in law to provide assurances to financers that they are not evaluating a potential moving target • Ensure that there is a project contingency to fund changes in law • Conduct regular meetings with legislators to assess potential concerns and the likelihood of legislative changes
	Other delay in funding process Examples:	See above

Table D-2. Project Phase: Project Scoping (including project delivery and funding / financing)

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
	• Approvals for grant funding or public loans (reduced and/or delayed funding) • Process complexity leads to delays • Revenue projections not strong enough to support/get required funding	
	Actual revenues significantly less than anticipated Examples: • Ability of concessionaire to live up to contract obligations • Bankruptcy of the concessionaire • For projects using availability payments, ability of agency to fund overruns • Impacts to O&M	In addition to the above: • Realistically determine whether the commercial deal is good for both sides • Use contracts that allow the agency to take over the project in event of financially distressed concessionaire • Ensure that the concessionaire has strong financial balance sheet • Develop a policy for how to establish and use reserves

Table D-2. Project Phase: Project Scoping (including project delivery and funding / financing)

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
Use alternative bonding or performance security Examples: • Letters of credit • Corporate guarantees		The following potential risk-management actions could apply to a number of the risk categories in the column to the left: • Re-package the project (e.g., multiple, smaller projects with multiple contractors) to accommodate surety market or bonding capacity • Secure payment bond to protect subcontractors
	Surety market cannot support project's bond requirements Examples: • Contractual risks are too great • Duration of performance obligations are too long • Overall bond amounts are too great	In addition to the above: • Outreach to the surety market on the overall agency program as well as project specific terms and conditions • For projects in excess of $250 million, consider reducing bonding amounts • Evaluate legislative changes needed to have flexibility in bonding terms (including amount) • Use contracts that have reasonable risk allocation • Consider using a combination of bonds, letters of credit and guarantees on larger projects
	Bonding capability of contractor(s) not adequate Examples: • Project is considered too long in duration to tie up bonding capacity • Dollar value of project exceeds bonding limits	In addition to the above: • Outreach to the contracting community • Allow joint ventures • Consider using "staged" bonds, where warranty obligations are covered by a separate bond rather than the performance bond
	Lack of payment bond results in subcontractor protests or claims (subcontractors view that their	In addition to the above:

Table D-2. Project Phase: Project Scoping (including project delivery and funding / financing)

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
	payment rights are unprotected)	• Require payment bonds to be issued, even if the dollar value is less than the full contract value • Create trust fund obligations through legislation
	Contractor defaults (various degrees of severity)	In addition to the above: • Ensure that the contract has appropriate take-over language in the event of a default • Ensure that the performance security is stable and available • Provide notice to the surety of a problem • Develop payment provisions that do not allow the contractor to front-end load and be too far ahead of owner

Table D-3. Project Phase: Environmental Process

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
Accelerate the environmental documentation process Examples: • Leverage master planning (see Project Scoping) • Conduct early coordination (see Planning) • Identify documentation requirements early • Identify and avoid major impacts early (historical, cultural, archaeological)	Note: the individual risk categories (and their related examples, below) might apply to any or all of the renewal category examples (shown to the left).	
	Different type of documentation required Example causes or issues: • Project's impacts are greater than originally assumed (due to design changes, originally underestimated impacts, etc.), so more substantial documentation is required (e.g., EIS instead of EA) • Additional discipline studies are required • Additional (new) alternatives must be developed and documented • Documentation requirements change	The following potential risk-management actions could apply to a number of the risk categories in the column to the left: • Modify the project design to reduce the impacts that are triggering different type of documentation • Anticipate potential concerns with main alternatives, and develop additional alternatives early in process to address those concerns • Anticipate/plan for and/or start additional (targeted) discipline studies earlier to reduce impact to project schedule if they are later required • Develop alternate (or additional/more-detailed) documentation in parallel with presumed appropriate documentation to reduce impact to schedule if alternate documentation is later required

Table D-3. Project Phase: Environmental Process

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
	Additional documentation required (but not a change in document type) Example causes or issues: • Project's impacts are greater than originally assumed (due to design changes, originally underestimated impacts, uncertain impacts from new rapid-renewal methods, etc.) • Additional discipline studies are required (e.g., more-extensive cultural survey) • Additional (new) alternatives must be developed and documented	Similar to above

	Other delay to completion of environmental process related to attempted acceleration
	
	Example causes or issues:
	• Discipline studies take longer than planned in the accelerated schedule (e.g., gathering growing-season data)
	• Signatory agencies unable to accommodate accelerated process (e.g., consultation on Biological Assessment takes longer than planned; lack of staff to participate in accelerated process pre-approval; indecisive agency)
	• Stakeholders resistant to accelerated process (e.g., feel uncomfortable or "rushed" by the accelerated process)
		• Early on, identify a quick-response team to address problems with the accelerated environmental process (might include actions listed below)
		• Early on, develop a contingency plan to accelerate discipline studies. For example:
		  o Establish on-call contracts with discipline specialists who might be needed later
		  o Identify additional staffing
		  o Develop solutions for issues obtaining rights-of-entry for field visits
		• If not already done, provide staffing support for signatory agencies (and plan for it early so it's ready to go when needed)
		• If not already done, increase public and stakeholder outreach related to the accelerated process to ease concerns about the process

Table D-3. Project Phase: Environmental Process

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
Seek streamlined environmental approval process / approvals Examples: • Resolve appropriate environmental document type early • Seek streamlined Biological Assessment / consultation process • Provide staff to signatory agencies to expedite review		

	Approval / signatory organizations cannot accommodate streamlined processing / approval
	
	Example causes or issues:
	• Inadequate staffing or heavy workload
	• Incompatible process/procedures
	• Unresolved or unclear requirements
	• Unresolved disputes or agreements
		• Early on, develop a contingency plan to mitigate problems with streamlined processing/approval. For example:
		  o Identify a 'quick-response team' to address problems with the process
		  o If not already done, provide staffing support for signatory agencies (and plan for it early so it's ready to go when needed)
		  o If not already done, establish a process to quickly resolve differences/disputes or clarify requirements
		• If not already done, increase public and stakeholder outreach related to the accelerated process to ease concerns about the process

Table D-3. Project Phase: Environmental Process

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
	Review and approval process takes longer than anticipated for other reasons Example causes or issues: • Receive larger number or more-substantial comments (e.g., on draft document or to specific discipline reports) than anticipated	See all above
	Challenge to environmental documentation once determination has been issued Example causes or issues: • Challenge to determination by stakeholder or other third party, whether viable or frivolous	• Identify potential future sources of challenges and monitor (or perhaps even engage them positively) • Early on, develop a contingency plan to respond to a challenge if it occurs. For example: o Potentially take actions as outlined earlier for environmental documentation and process (above) o Identify on-call legal resources o Identify potential bargaining position (mitigation, design change, etc.), including securing relevant policy decisions/positions from leadership
Pursue accelerated environmental permitting Examples: • Develop permit applications coincident with design • Learn requirements early • Form multi-agency permitting teams (dispute resolution)		

Table D-3. Project Phase: Environmental Process

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
• Provide staff to signatory agencies to expedite review		
	Development of permit application takes longer than anticipated Example causes or issues: • Project's impacts are greater than originally assumed (due to design changes, originally underestimated impacts, etc.) • Permit conditions different than anticipated (especially resulting from uncertainty in rapid-renewal element permitting) • Late changes to project design or environmental documentation	• Early on, develop a contingency plan to accelerate development of the permit application. For example: o Establish on-call contracts with discipline specialists who might be needed later o Identify additional staffing o Anticipate potential disputes over unclear requirements and work to avoid them • If not already done, provide staffing support for reviewing agencies (and plan for it early so it's ready to go when needed) • If not already done, increase public and stakeholder outreach related to the accelerated process to ease concerns about the process
	Delay in permit review or approval Example causes or issues: • Permitting agency uncomfortable with rapid-renewal elements • Stakeholders withhold support • Agency unable to manage or is not staffed for accelerated permitting process	• Early on, develop a contingency plan to mitigate problems with streamlined permit processing/approval. For example: o Identify a 'quick-response team' to address problems with the process o If not already done, provide staffing support for reviewing agencies (and plan for it early so it's ready to go when needed)

Table D-3. Project Phase: Environmental Process

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
		o If not already done, establish a process to quickly resolve differences/disputes or clarify requirements

Table D-3. Project Phase: Environmental Process

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
	Unanticipated or additional permits required Example causes or issues: • Project's impacts are greater than originally assumed (due to design changes, originally underestimated impacts, etc.) • Permit conditions different than anticipated (especially resulting from uncertainty in rapid-renewal element permitting)	See above
	Challenge to permits once issued Example causes or issues: • Stakeholders or opposition groups attempt to hold up project	• Identify potential future sources of challenges and monitor (or perhaps even engage them positively) • Early on, develop a contingency plan to respond to a challenge if it occurs. For example: o Potentially take actions as outlined earlier for permit development (above) o Identify on-call legal resources o Identify potential bargaining position (mitigation, design change, etc.), including securing relevant policy decisions/positions from leadership
Streamline mitigation planning and implementation Examples: • Utilize wetland banks • Leverage/improve existing mitigation sites (onsite or offsite), potentially including partnering with other		

Table D-3. Project Phase: Environmental Process

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
agencies • Proactively implement noise or view mitigation		
	Streamlined mitigation effort won't work (management issue) Example causes or issues: • Stakeholder or governing agency doesn't approve plan (e.g., doesn't acknowledge or believe that the plan will work; mitigation not in same drainage basin as impacts) • Unforeseen regulatory constraint • Unable to acquire required mitigation site (or unacceptable delay)	• Early on, develop a contingency plan to respond to a overcome resistance to the proposed mitigation plan if it occurs. For example: o Anticipate potential concerns with the proposed mitigation plan, and develop additional alternative mitigation concepts early in design to address those concerns o Identify potential bargaining position (different or more mitigation, design change, etc.), including securing relevant policy decisions/positions from leadership
	Streamlined mitigation effort won't work (technical issue) Example causes or issues: • Plan doesn't adequately mitigate impacts (e.g., need more or different mitigation) • Plan not feasible from a technical standpoint (e.g., can't sustain over time) • Wetland bank fails and can't supply project's mitigation	• Modify the design to reduce impacts • Anticipate potential technical issues with the proposed mitigation plan, and develop additional alternative mitigation concepts early in design to address those issues

Table D-4a. Project Phase: Design and Construction (General Principles)

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
Accelerate the design process Examples: • Overlap design activities (make less sequential) • Involve stakeholders early • Learn requirements and constraints early • Resolve significant design decisions early • Equally develop and 'carry' multiple alternatives until selection of preferred alternative • Ensure adequate staffing • Employ design exceptions as strategy • Use standardized designs for repetitive items		
	Key design decisions are delayed Example causes or issues: • Technical – the current design has a significant technical problem • Management – the current design does not have management support • Political – the current design does not have political support or meet existing political commitments Note: this type of delay could result from (and be included under) other risk categories listed in this document. Don't double-count impacts.	• Early on, develop a contingency plan to accelerate design in the face of decision delays. For example: o Establish on-call contracts with discipline specialists who might be needed later o Identify additional staffing o Develop alternative design concepts and/or carry parallel design documentation to reduce impacts
	Other key project-related decisions are delayed or changed	Similar to above

Table D-4a. Project Phase: Design and Construction (General Principles)

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
	Example causes or issues: • Funding delayed • Purpose and need, project definition, and/or scope significantly modified late in design, requiring re-design • Project delivery method changed (which affects design documentation) Note: this type of delay could result from (and be included under) other risk categories listed in this document. Don't double-count impacts.	
	Stakeholders not able (or willing) to support accelerated design process Example causes or issues: • Not able to make internal decisions or provide input on accelerated schedule • Do not support current alternative	• Early on, develop a contingency plan to respond to and overcome potential inability to support or resistance to the proposed design. For example: o Anticipate potential concerns with the proposed design, and develop additional alternatives or concepts early in design to address those concerns o Identify potential bargaining position (design change, mitigation, etc.), including securing relevant policy decisions/positions from leadership o Provide staffing support to stakeholders to educate stakeholders on and/or help them evaluate the design
	Encounter unanticipated changes in design standards Example causes or issues:	• Reduce the likelihood of being 'surprised' by conducting frequent searches for potential design changes /

Table D-4a. Project Phase: Design and Construction (General Principles)

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
	• Seismic (geotechnical, structural) • Hydraulic/stormwater • Environmental Note: could be covered separately under specific design disciplines.	stay in contact with issuing agencies • Reduce the impacts if a change occurs by evaluating impacts from potential standards changes early; potentially carry develop multiple design alternatives • Employ performance specifications to allow for contractor innovation
	Standardized designs not available or suitable Example causes or issues: • Not cost-effective or technically effective	• Modify design (or specs) to allow standardized designs (when feasible) • Develop standardized designs for repeatable elements (if possible)
	Delay in approval of design exceptions, or denial of design exceptions Example causes or issues: • Requested exceptions create too many adverse impacts • Requested exceptions not acceptable for other reasons (e.g., stakeholder concerns)	• Early on, develop a contingency plan to accelerate approval of design exceptions. For example: o Document how proposed design achieves objectives despite (or perhaps because of) proposed exceptions o Develop process for rapidly resolving any issues with approval authority • Early on, develop a contingency plan to mitigate impacts of denial of exceptions. For example: o Develop alternative design concepts and/or carry parallel design documentation to reduce impacts
	Staffing for accelerated design not available Example causes or issues:	• Early on, develop a contingency plan to accelerate design in the face of staffing

Table D-4a. Project Phase: Design and Construction (General Principles)

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions

	• Staffing re-directed to higher priorities
	• Key technical staff not available at critical times
		issues. For example (if not already done):
		  o Establish on-call contracts with discipline specialists who might be needed later
		  o Identify additional staffing
		• Employ performance specifications to allow for contractor innovation

Seek streamlined design approvals Examples: • Speed processing by providing staff support to approval authority • Coordinate early and often with approval authority		

	Owning agency not staffed or structured for streamlined approvals
	
	Example causes or issues:
	• Workload too great or right staff not available
	• Existing process doesn't accommodate accelerated approvals
		• Early on, develop a contingency plan to mitigate problems with streamlined processing/approval. For example:
		  o Identify a 'quick-response team' to address problems with the process
		  o Establish on-call contracts with discipline specialists who might be needed during approvals process
		  o Identify additional internal staffing and have 'on-hand'

	Stakeholders unable or unwilling to accommodate streamlined approvals Example causes or issues: • Not able to review or make internal	• Early on, develop a contingency plan to mitigate problems with streamlined processing/approval. For example: o Identify a 'quick-response team'

Table D-4a. Project Phase: Design and Construction (General Principles)

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
	decisions/approvals on the streamlined schedule • Do not support submitted design	to address problems with the process o If not already done, provide staffing support for approving stakeholders (and plan for it early so it's ready to go when needed) o If not already done, establish a process to quickly resolve differences/disputes or clarify requirements
	Delays to other activities delay the design's approval Example causes or issues: • Delay to environmental process • Delay to permitting Note: this type of delay could result from (and be included under) other risk categories listed in this document. Don't double-count impacts.	• Conduct early and frequent coordination with other disciplines, and assess potential impacts to design from delays to those activities • Elevate issues for higher (and hopefully more timely) resolution
	Mistakes in the design delay the design's approval Example causes or issues: • Mistakes resulting from accelerated pace of the design process (e.g., incomplete or inadequate checks and reviews)	• Conduct concept and design reviews (internal or external) early on to identify potential problems • Conduct early and frequent coordination with other disciplines to avoid miscommunication, misunderstanding, etc. • Have accelerated design approval process in place (if don't already) to mitigate delay
Hold industry constructability reviews early		

Table D-4a. Project Phase: Design and Construction (General Principles)

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
Examples: • Engage non-bidding contractors to review and ‘war game’ construction phasing plan • Seek contractor opinion (non-conflicted) on potential new rapid-renewal construction techniques • Seek contractor opinion (non-conflicted) on other ways to accelerate construction (e.g., overlap activities)		
	Constructability review not allowed (policy) Example causes or issues: • Concerns about conflicts of interest • Other existing policy prohibits engaging contracting industry for this purpose	• Seek change in policy early on to allow reviews when needed
	Constructability review not successful Example causes or issues: • Unable to engage qualified contractors with no conflicts of interest • Feedback is biased or otherwise unreliable or unhelpful	• Early on, ensure have a viable pool of independent and available contractors (e.g., perhaps by using retired or out-of-town contractors)
	Constructability review successful, but leads to significant changes in design Example causes or issues: • Fatal flaw found, requiring re-design • Significant change in concept recommended	• Hold reviews early so that impact to design schedule is minimized • Be ready to make quick decisions on contractor recommendations (e.g., elevate and quickly resolve)

Table D-4a. Project Phase: Design and Construction (General Principles)

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
	and reviewed/accepted, leading to re-design	• Develop and carry alternative designs and/or construction phasing/staging plans throughout the design process (one might reflect contractor recommendations)

Table D-4b. Project Phase: Design and Construction - Structures

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
Use innovative and/or long-life designs		
	Innovative and long-life designs not the right solution Example causes or issues: • Inadequate funding • Adequate funding but innovative and long-life designs are not the most cost-effective approach • Innovative designs too "risky" (e.g., no demonstrated performance history; uncertain constructability) • Interim (short-term) solution more appropriate (e.g., adjacent or follow-on project will build permanent solution)	• Develop additional alternatives or concepts early in design to reduce delay if innovative or long-life designs don't work out • Secure funding in advance for long-life designs • Gather performance information for innovative designs early (before selecting design) • Coordinate with adjacent projects early to better anticipate any interim solutions required from current project
Use alternative and/or long-life materials Examples: • High-performance steel • High-performance concrete • Lightweight aggregates • Fiber reinforcement		
	Candidate materials won't work (technical issues identified during design) Example causes or issues: • Can't get materials permitted • Planned materials not the best choice for desired structure (e.g., strength, stiffness, durability, cost) • Planned materials too "risky" (e.g., no	• Test materials and materials designs early on pilot section or parallel project of smaller scale • Develop additional alternatives or concepts early in design to reduce delay if candidate materials don't work out • Gather performance information for

Table D-4b. Project Phase: Design and Construction - Structures

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
	demonstrated performance history) • Other project conditions preclude the materials' application (e.g., too cold during construction)	candidate materials early (before selecting them for design) (i.e., evaluate feasibility early on)
	Delay in procuring candidate materials Example causes or issues: • Inadequate supply when needed (delay); for example, material supply source doesn't meet environmental requirements • Costs higher (other than because of limited supply) and/or benefits not as great as anticipated, so delay in decision to use the materials • Required expertise in using materials not available when needed	• Early on, identify material sources and evaluate potential availability (i.e., conduct feasibility study) • Have contractors guarantee supply in contract, or make provisions for schedule recovery or use of alternative, equivalent materials if material procurement is delayed
Re-use or rehabilitate existing components Examples: • Rehab columns and piers • Rehab bridge decks • Supplement existing foundations		
	Rehabilitation not the best option (identified during design) Example causes or issues: • Replacement turns out to be more technically viable o Improved compatibility with new structures o Difficulty performing rehabilitation o Rehabilitation does not provide desired performance	• In parallel, develop design for replacement/new structure (to reduce delay if rehabilitation turns out to not be the best option) • Gather/confirm technical and cost performance information for existing structures early in design, to help make early decisions on approach and funding

Table D-4b. Project Phase: Design and Construction - Structures

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
	• Replacement turns out to be more cost-effective (e.g., due to limited amount of rehabilitation required)	
	Problems with rehabilitation during construction Example causes or issues: • Discover that more or different rehabilitation is required (e.g., selected technique won't deliver required performance) • Discover that rehabilitation won't work (e.g., structure is in worse condition than previously believed)	• Either internally or through contractor: Try to anticipate potential problems in advance, and then develop alternative designs and/or remedial measures to reduce delay if problems occur • Select contractor with demonstrated success in candidate rehabilitation methods • Ensure contract provisions allow for rapid and fair resolution of these issues
Pre-fabricate key elements Examples: • Full-depth decks • Partial-depth decks • Decks with girders • Decks with barriers • Retaining-wall panels • Noise-wall panels		
	Candidate pre-fabrication technique won't work (technical issues identified during design) Example causes or issues: • Transportation of pre-fabricated elements difficult or not possible • Inadequate site access (e.g., can't maneuver on-site) • Planned structure not suitable for construction via pre-fabricated elements • Other project conditions preclude the use of	• In parallel, develop design for alternative pre-fabrication or on-site fabrication (to reduce delay if pre-fabrication turns out to not be the best option) • Gather/confirm technical and cost performance information for pre-fabricating structures early in design, to help make early decisions on approach, procurement, and funding

Table D-4b. Project Phase: Design and Construction - Structures

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
	pre-fabrication	• Employ performance specifications to allow for contractor innovation
	Delay in procuring pre-fabricated elements Example causes or issues: • Fabrication facility not available when needed • Problems with design (e.g., errors) or constructability discovered during fabrication process • Costs higher and/or benefits not as great as anticipated, so delay in decision to use the pre-fabricated elements	• Early on, identify fabricators and evaluate potential availability of required items (i.e., conduct feasibility study) • Have contractors guarantee availability and schedule of pre-fabricated items in contract, or make provisions for schedule recovery if procurement is delayed
	Problems with pre-fabricated elements during construction Example causes or issues: • Specialized construction equipment malfunctions or breaks down • Difficulty maneuvering pre-fabricated elements • Damage pre-fabricated elements during erection • Other construction-related accident	• Either internally or through contractor: Try to anticipate potential problems in advance, and then develop alternative designs and/or remedial measures to reduce delay if problems occur • Select contractor with demonstrated success in candidate pre-fabricated construction • Ensure contract provisions allow for rapid and fair resolution of these issues
Use rapid-placement/construction techniques Examples: • Longitudinal launching • Horizontal skidding • Self-propelled modular transporters (SPMTs) • Barges • Temporary structures		

Table D-4b. Project Phase: Design and Construction - Structures

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
	Candidate rapid-placement technique won't work (technical issues identified during design) Example causes or issues: • Inadequate access (e.g., can't get SPMTs into position) • Can't get technique permitted • Planned structure not suitable for construction via the technique • SPMTs will cross utilities that cannot be disrupted • Other project conditions preclude the technique's application	• In parallel, develop design for alternative rapid-replacement or accelerated traditional technique (to reduce delay if chosen rapid-replacement technique turns out to not be the best option) • Gather/confirm technical and cost performance information for the intended rapid-replacement technique early in design, to help make early decisions on approach, procurement, and funding • Coordinate with affected utilities early in the process and provide partnering facilitator if needed • Employ performance specifications to allow for contractor innovation
	Delay in procuring rapid-replacement equipment and/or specialized labor Example causes or issues: • Specialized equipment or labor not available when needed • Costs higher and/or benefits not as great as anticipated, so delay in decision to use the technique	• Early on, identify sources of relevant equipment and labor, and evaluate potential availability (i.e., conduct feasibility study) • Have contractors guarantee availability and schedule of specialized equipment items in contract, or make provisions for schedule recovery (e.g., alternative equipment; alternative construction method) if procurement is delayed
	Problems with rapid-replacement technique during construction Example causes or issues: • Specialized equipment malfunctions or breaks down	• Either internally or through contractor: Try to anticipate potential problems in advance, and then develop alternative designs (using alternative construction techniques) and/or remedial measures

Table D-4b. Project Phase: Design and Construction - Structures

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
	• Technique doesn't work as intended (various reasons) • Construction accident	(for selected technique) to reduce delay if problems occur • Select contractor with demonstrated success using the proposed rapid-placement technique • Ensure contract provisions allow for rapid and fair resolution of these issues • Conduct thorough survey of existing conditions, including independent peer review • Develop contingency plans for the case that technique does not work as intended

Table D-4c. Project Phase: Design and Construction – Geotechnical and Earthwork

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
Use innovative and long-life designs		
	Innovative and long-life designs not the right solution Example causes or issues: • Inadequate funding • Adequate funding but innovative and long-life designs not the most cost-effective approach • Innovative designs too "risky" (e.g., no demonstrated performance history; uncertain constructability) • Interim (short-term) solution more appropriate (e.g., follow-on project will build permanent solution)	• Develop additional alternatives or concepts early in design to reduce delay if innovative or long-life designs don't work out • Secure funding in advance for long-life designs • Gather performance information for innovative designs early (before selecting design) • Coordinate with adjacent projects early to better anticipate any interim solutions required from current project
Use alternative and/or long-life materials Examples: • Flowable fill; foamed concrete; geofoam • Stabilize subgrade (e.g., with fly ash)		
	Candidate materials won't work (technical issues identified during design) Example causes or issues: • Can't get materials permitted • Planned materials not the best choice for desired geotechnical structure (e.g., strength, hydraulic conductivity, compressibility, durability, cost) • Planned materials too "risky" (e.g., no	• Test materials and materials designs early on pilot section or parallel project of smaller scale • Develop additional alternatives or concepts early in design to reduce delay if candidate materials don't work out • Gather performance information for candidate materials early (before

Table D-4c. Project Phase: Design and Construction – Geotechnical and Earthwork

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
	demonstrated performance history) • Other project conditions preclude the materials' application (e.g., too cold during construction)	selecting them for design) (i.e., evaluate feasibility early on) • Employ performance specifications to allow for contractor innovation
	Delay in procuring candidate materials Example causes or issues: • Inadequate supply when needed (delay); for example, material supply source doesn't meet environmental requirements • Costs higher (other than because of limited supply) and/or benefits not as great as anticipated, so delay in decision to use the materials • Required expertise in using materials not available when needed	• Early on, identify material sources and evaluate potential availability (i.e., conduct feasibility study) • Have contractors guarantee supply in contract, or make provisions for schedule recovery or use of alternative, equivalent materials if material procurement is delayed
Re-use or rehabilitate existing components Examples: • Supplement existing foundations (e.g., micropiles • Stabilize existing foundations (e.g., with ground support)		

	Rehabilitation not the best option (identified during design)
	
	Example causes or issues:
	• Replacement turns out to be more technically viable
	  o Improved compatibility with new structures
	  o Difficulty performing rehabilitation
		• In parallel, develop design for replacement/new structure (to reduce delay if rehabilitation turns out to not be the best option)
		• Gather/confirm technical and cost performance information for existing structures early in design, to help make early decisions on approach and

Table D-4c. Project Phase: Design and Construction – Geotechnical and Earthwork

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
	o Rehabilitation does not provide desired performance • Replacement turns out to be more cost-effective (e.g., due to limited amount of rehabilitation required)	funding
	Problems with rehabilitation during construction Example causes or issues: • Discover that more or different rehabilitation is required (e.g., selected technique won't deliver required performance) • Discover that rehabilitation won't work (e.g., foundation or structure is in worse condition than previously believed) • Construction accident	• Either internally or through contractor: Try to anticipate potential problems in advance, and then develop alternative designs and/or remedial measures to reduce delay if problems occur • Select contractor with demonstrated success in candidate rehabilitation methods • Ensure contract provisions allow for rapid and fair resolution of these issues
Pre-fabricate key elements		
	Candidate pre-fabrication technique won't work (technical issues identified during design) Example causes or issues: • Transportation of pre-fabricated elements difficult or not possible • Inadequate site access (e.g., can't maneuver on-site) • Planned geotechnical structure not suitable for construction via pre-fabricated elements • Other project conditions preclude the use of pre-fabrication	• In parallel, develop design for alternative pre-fabrication or on-site fabrication (to reduce delay if pre-fabrication turns out to not be the best option) • Gather/confirm technical and cost performance information for pre-fabricating geotechnical structures early in design, to help make early decisions on approach, procurement, and funding • Employ performance specifications to allow for contractor innovation
	Delay in procuring pre-fabricated elements Example causes or issues: • Fabrication facility not available when needed	• Early on, identify fabricators and evaluate potential availability of required items (i.e., conduct feasibility study)

Table D-4c. Project Phase: Design and Construction – Geotechnical and Earthwork

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
	• Problems with design (e.g., errors) or constructability discovered during fabrication • Costs higher and/or benefits not as great as anticipated, so delay in decision to use the pre-fabricated elements	• Have contractors guarantee availability and schedule of pre-fabricated items in contract, or make provisions for schedule recovery if procurement is delayed
	Problems with pre-fabricated elements during construction Example causes or issues: • Specialized construction equipment malfunctions or breaks down • Difficulty maneuvering pre-fabricated elements • Damage pre-fabricated elements during construction • Other construction-related accident	• Either internally or through contractor: Try to anticipate potential problems in advance, and then develop alternative designs and/or remedial measures to reduce delay if problems occur • Select contractor with demonstrated success in candidate pre-fabricated construction • Ensure contract provisions allow for rapid and fair resolution of these issues

Table D-4c. Project Phase: Design and Construction – Geotechnical and Earthwork

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
Use rapid-placement/construction techniques Examples: • Top-down excavation support • Innovative ground improvement • Rapid-embankment consolidation / construction • Intelligent compaction equipment		
	Candidate rapid-placement technique won't work (technical issues identified during design) Example causes or issues: • Inadequate access (e.g., can't get specialized equipment into position) • Can't get technique permitted • Planned geotechnical structure not suitable for construction via the technique • Other project conditions preclude the technique's application	• In parallel, develop design for alternative rapid-replacement or accelerated traditional technique (to reduce delay if chosen rapid-replacement technique turns out to not be the best option) • Gather/confirm technical and cost performance information for the intended rapid-replacement technique early in design, to help make early decisions on approach, procurement, and funding
	Delay in procuring rapid-replacement equipment and/or specialized labor Example causes or issues: • Specialized equipment or labor not available when needed • Costs higher and/or benefits not as great as anticipated, so delay in decision to use the technique	• Early on, identify sources of relevant equipment and labor, and evaluate potential availability (i.e., conduct feasibility study) • Have contractors guarantee availability and schedule of specialized equipment items in contract, or make provisions for schedule recovery (e.g., alternative

Table D-4c. Project Phase: Design and Construction – Geotechnical and Earthwork

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
		equipment; alternative construction method) if procurement is delayed
	Problems with rapid-placement technique during construction Example causes or issues: • Specialized equipment malfunctions or breaks down • Technique doesn't work as intended (various reasons) • Construction accident	• Either internally or through contractor: Try to anticipate potential problems in advance, and then develop alternative designs (using alternative construction techniques) and/or remedial measures (for selected technique) to reduce delay if problems occur • Select contractor with demonstrated success using the proposed rapid-placement technique • Ensure contract provisions allow for rapid and fair resolution of these issues

Table D-4d. Project Phase: Design and Construction – Drainage / Stormwater Management

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
Use innovative and long-life designs Examples: • Seek sustainable/natural solutions for treatment		• Work with interdisciplinary team to identify alternative locations and technologies to assist in drainage / stormwater management
	Innovative and/or long-life designs not the right solution Example causes or issues: • Innovative and long-life designs are not the most cost-effective or schedule appropriate approach • Innovative designs too "risky" (e.g., no demonstrated performance history; uncertain constructability) • Interim (short-term) solution more appropriate (e.g., adjacent or follow-on project will build permanent solution)	
Use alternative and/or long-life materials Examples: • Natural materials for conveyance, detention, and treatment structures/ponds • Utilize materials that allow for rapid installation and subsequent construction		

Table D-4d. Project Phase: Design and Construction – Drainage / Stormwater Management

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
	Candidate materials won't work (technical issues identified during design) Example causes or issues: • Can't get materials permitted • Planned materials will not work within project physical project constraints • Planned materials too "risky" (e.g., no demonstrated performance history)	• Test materials and materials designs early on pilot section or parallel project of smaller scale • Concurrently create a design with traditional material as a contingency • Develop contingency plans to achieve rapid construction via more traditional means (e.g., phased placement, alternative shifts, etc.) • Gather performance information for candidate materials early (before selecting them for design) (i.e., evaluate feasibility early on) • Employ performance specifications to allow for contractor innovation
	Delay in procuring candidate materials Example causes or issues: • Inadequate supply when needed (delay); for example, material supply source doesn't meet environmental requirements • Costs higher (other than because of limited supply) and/or benefits not as great as anticipated, so delay in decision to use the materials • Required expertise in using materials not available when needed	• Early on, identify material sources and evaluate potential availability (i.e., conduct feasibility study) • Have contractors guarantee supply in contract, or make provisions for schedule recovery or use of alternative, equivalent materials if material procurement is delayed
Re-use or rehabilitate existing components Examples: • Culverts • Tie into existing drainage system (outfalls, treatment)		The following potential risk-management actions could apply to a number of the risk categories in the column to the left: • Conduct early testing of existing components • Explore designs that involve modifications to existing components

Table D-4d. Project Phase: Design and Construction – Drainage / Stormwater Management

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions

	Rehabilitation not the best option (identified during design)
	
	Example causes or issues:
	• Replacement turns out to be more technically viable
	  o Improved compatibility with new drainage facilities
	  o Difficulty performing rehabilitation
	  o Rehabilitation does not provide desired performance
	• Replacement turns out to be more cost-effective (e.g., due to limited amount of rehabilitation required)
		• In parallel, develop design for replacement/new drainage facility (to reduce delay if rehabilitation turns out to not be the best option)
		• Gather/confirm technical and cost performance information for existing facility early in design, to help make early decisions on approach and funding

	Problems with rehabilitation during construction Example causes or issues: • Discover that more or different rehabilitation is required (e.g., selected technique won't deliver required performance) • Discover that rehabilitation won't work (e.g., existing drainage facility is in worse condition than previously believed) • Construction accident	• Either internally or through contractor: Try to anticipate potential problems in advance, and then develop alternative designs and/or remedial measures to reduce delay if problems occur • Select contractor with demonstrated success in candidate rehabilitation methods • Ensure contract provisions allow for rapid and fair resolution of these issues
Pre-fabricate key elements Examples: • Replacement culverts • Inlet and outlet structures		
	Candidate pre-fabrication technique won't work (technical issues identified during design) Example causes or issues:	• In parallel, develop design for alternative pre-fabrication or on-site fabrication (to reduce delay if pre-fabrication turns out to not be the best

Table D-4d. Project Phase: Design and Construction – Drainage / Stormwater Management

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
	• Transportation of pre-fabricated elements difficult or not possible • Inadequate site access (e.g., can't maneuver on-site) • Other project conditions preclude the use of pre-fabrication	option)
	Delay in procuring pre-fabricated elements Example causes or issues: • Fabrication facility not available when needed • Problems with design (e.g., errors) or constructability discovered during fabrication process • Costs higher and/or benefits not as great as anticipated, so delay in decision to use the pre-fabricated elements	• Early on, identify fabricators and evaluate potential availability of required items (i.e., conduct feasibility study) • Have contractors guarantee availability and schedule of pre-fabricated items in contract, or make provisions for schedule recovery if procurement is delayed
	Problems with pre-fabricated elements during construction Example causes or issues: • Specialized construction equipment malfunctions or breaks down • Difficulty maneuvering pre-fabricated elements • Damage pre-fabricated elements during construction • Other construction-related accident	• Either internally or through contractor: Try to anticipate potential problems in advance, and then develop alternative designs and/or remedial measures to reduce delay if problems occur • Select contractor with demonstrated success in candidate pre-fabricated construction • Ensure contract provisions allow for rapid and fair resolution of these issues

Table D-4e. Project Phase: Design and Construction – Roadway, Geometrics, and ITS

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
Use innovative and long-life designs Examples: • Consider alternative alignment / geometrics • Provide alternative access		The following potential risk-management actions could apply to a number of the risk categories in the column to the left: • Conduct early and thorough investigation of existing alignment / geometrics to optimize reuse and minimize disruption during construction • Study use of alternative technical solutions for ITS that may allow for reuse of existing infrastructure • Develop additional alternatives or concepts early in design to reduce delay if innovative or long-life designs don't work out • Secure funding in advance for long-life designs • Gather performance information for innovative designs early (before selecting design)
	Innovative designs require exemptions from FHWA or other agency Examples: • Alternative alignment does not meet current design standards • Innovative ITS design does not meet the approval of FHWA under current standards	
Use alternative and long-life equipment Examples: • Ensure compatibility with existing system		

Table D-4e. Project Phase: Design and Construction – Roadway, Geometrics, and ITS

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
	Candidate equipment won't work (technical issues identified during design) Example causes or issues: • Planned equipment not compatible with equipment in adjacent locations • Planned materials too "risky" (e.g., no demonstrated performance history)	
Re-use or rehabilitate existing components Examples: • Fiber backbone • Communications equipment		
	Testing of existing components is not reliable Examples: • Existing components cannot be accessed for testing • Adequate testing methods not available • Testing samples do not reflect the condition of the entire component	
	Existing component will not be compatible with new design or construction method Examples: • Impossible to integrate existing component with new design • Existing component will be damaged during construction	

Table D-4f. Project Phase: Design and Construction – Pavement

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
Use innovative and long-life designs Examples: • Conduct life-cycle analysis (e.g., asphalt vs. concrete) • Consider maintenance requirements • Establish performance indicators	**Innovative and long-life designs not the right solution** Example causes or issues: • Inadequate funding • Adequate funding but innovative and long-life designs not the most cost-effective approach • Innovative designs too "risky" (e.g., no demonstrated performance history; uncertain constructability) • Interim (short-term) solution more appropriate (e.g., follow-on project will build permanent solution)	• Develop additional alternatives or concepts early in design to reduce delay if innovative or long-life designs don't work out • Secure funding in advance for long-life designs • Gather performance information for innovative designs early (before selecting design) • Coordinate with adjacent projects early to better anticipate any interim solutions required from current project • Employ performance specifications to allow for contractor innovation
Use alternative and long-life materials Examples: • Stone matrix asphalt (SMA) • Continuously-reinforced concrete pavement (CRCP) • Polymer asphalt • Composite pavement • Sub-grade treatment/stabilization		
	Candidate materials won't work (technical issues identified during design) Example causes or issues: • Can't get materials permitted • Planned materials not the best choice for desired pavement performance (e.g., durability, cost)	• Test materials and materials designs early on pilot section or parallel project of smaller scale • Develop additional alternatives or concepts early in design to reduce delay if candidate materials don't work out

Table D-4f. Project Phase: Design and Construction – Pavement

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
	• Planned materials too "risky" (e.g., no demonstrated performance history) • Other project conditions preclude the materials' application (e.g., too cold during construction)	• Gather performance information for candidate materials early (before selecting them for design) (i.e., evaluate feasibility early on) • Employ performance specifications to allow for contractor innovation
	Delay in procuring candidate materials Example causes or issues: • Inadequate supply when needed (delay); for example, material supply source doesn't meet environmental requirements • Costs higher (other than because of limited supply) and/or benefits not as great as anticipated, so delay in decision to use the materials • Required expertise in using materials not available when needed	• Early on, identify material sources and evaluate potential availability (i.e., conduct feasibility study) • Have contractors guarantee supply in contract, or make provisions for schedule recovery or use of alternative, equivalent materials if material procurement is delayed
Re-use or rehabilitate existing components Examples: • Rubblize / recycle existing pavement		

	Rehabilitation not the best option (identified during design)
	
	Example causes or issues:
	• Replacement turns out to be more technically viable
	    o Improved compatibility with new or adjacent pavement sections
	    o Difficulty performing rehabilitation
	    o Rehabilitation does not provide
		• In parallel, develop design for replacement pavement alternative (to reduce delay if rehabilitation turns out to not be the best option)
		• Gather/confirm technical and cost performance information for existing pavement early in design, to help make early decisions on approach and funding

Table D-4f. Project Phase: Design and Construction – Pavement

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
	desired performance • Replacement turns out to be more cost-effective (e.g., due to limited amount of rehabilitation required)	
	Problems with rehabilitation during construction Example causes or issues: • Discover that more or different rehabilitation is required (e.g., selected technique won't deliver required performance) • Discover that rehabilitation won't work (e.g., pavement is in worse condition than previously believed) • Construction accident	• Either internally or through contractor: Try to anticipate potential problems in advance, and then develop alternative designs and/or remedial measures to reduce delay if problems occur • Select contractor with demonstrated success in candidate rehabilitation methods • Ensure contract provisions allow for rapid and fair resolution of these issues
Pre-fabricate key elements Examples: • Roadway panels (concrete, pre-stressed)		
	Candidate pre-fabrication technique won't work (technical issues identified during design) Example causes or issues: • Transportation of pre-fabricated elements difficult or not possible • Inadequate site access (e.g., can't maneuver on-site) • Planned pavement section not suitable for construction via pre-fabricated elements • Other project conditions preclude the use of pre-fabrication	• In parallel, develop design for alternative pre-fabrication or on-site fabrication (to reduce delay if pre-fabrication turns out to not be the best option) • Gather/confirm technical and cost performance information for pre-fabricating pavement sections/panels early in design, to help make early decisions on approach, procurement, and funding
	Delay in procuring pre-fabricated elements Example causes or issues:	• Early on, identify fabricators and evaluate potential availability of required

Table D-4f. Project Phase: Design and Construction – Pavement

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
	• Fabrication facility not available when needed • Problems with design (e.g., errors) or constructability discovered during fabrication • Costs higher and/or benefits not as great as anticipated, so delay in decision to use the pre-fabricated elements	items (i.e., conduct feasibility study) • Have contractors guarantee availability and schedule of pre-fabricated items in contract, or make provisions for schedule recovery if procurement is delayed

Table D-4g. Project Phase: Design and Construction – Maintenance of Traffic (MOT)

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
		The following potential risk-management actions could apply to a number of the risk categories in the column to the left: • Use performance-based specs • Use contractor incentives at key coordination points within contract and between contracts in a phased situation • Reduce traffic demand during closures. Examples: o Provide alternative modes o Provide additional alternate routes • Conduct early coordination with agencies and other stakeholders. Examples: o Presentation of case studies o Additional outreach o Early preparation of business case for closure • Seek early contractor involvement / constructability reviews • Conduct detailed (or earlier) traffic and/or safety analysis • Develop multiple alternatives early, including alternative staging or closures • Develop contingency plan for implemented closures

Table D-4g. Project Phase: Design and Construction – Maintenance of Traffic (MOT)

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
Use innovative MOT strategies Examples: • Provide alternative modes • Provide alternative routes • Utilize creative closure strategies (incentive/disincentive; directional closures; total vs. partial closures) • Develop and 'carry' alternative MOT plans		
	Planned closures and related detour routes not allowed (management issue) Example causes or issues: • Local agency won't approve (various reasons) • Owning agency won't approve (various reasons) • Not viable/allowed by project delivery/contracting approach • Contractor won't reasonably bid the approach	
	Planned closures and related detour routes won't work (technical issue identified during design) Example causes or issues: • Unacceptable traffic capacity • Unacceptable safety impacts (to public or workers) • Unacceptable noise, dust, vibration, or other impacts to adjacent public	
	Planned closures and related routes are not the most efficient Example causes or issues:	

Table D-4g. Project Phase: Design and Construction – Maintenance of Traffic (MOT)

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
	• Another plan identified later which could work better (e.g., different or more closures; alternate routes instead of closures)	
	Implemented closure plan doesn't work (during construction) Example causes or issues: • Causes unacceptable traffic impacts • Creates unacceptable ancillary impacts (e.g., adjacent businesses)	
Test the MOT plan prior to construction Examples: • Simulate plan performance (e.g., using traffic models) • 'War game' the MOT plan with constructors (e.g., on a table-top project graphic, stepping through the construction staging/sequencing)	Similar to above.	

Table D-5a. Project Phase: Right-of-Way (ROW)

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
Accelerate ROW planning Examples: • Overlap ROW planning with project design and environmental activities • Coordinate early and often with design team • Carry multiple alternatives • Provide additional staff to support planning and appraisals • Approach sellers early with plans • Seek accelerated ROW funding • Seek streamlined ROW plan approval process		
	Late changes to the design cause delay in ROW planning Example causes or issues: • Change in design late in process cascades to ROW design changes (especially if ROW planning and design are overlapped), resulting in delay in agreements and/or ROW plan review/approval	• Early on, develop a contingency plan to accelerate ROW planning after late design changes. For example: o Develop and carry multiple design alternatives, and have corresponding ROW plans partially developed, to reduce impact if design changes o Coordinate early and often with design team o Early on, establish on-call contracts with real-estate appraisal specialists who might be needed later

Table D-5a. Project Phase: Right-of-Way (ROW)

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions

	ROW plans not completed as planned (other than from design changes)
	
	Example causes or issues:
	• Delay in review and/or approval of plans. For example:
	  o Design/planning schedule too aggressive
	  o Inadequate staffing
	  o Agency waiting for project funding or contractor NTP
	• Accelerating pace of development in project area triggers plan revision
		• Early on, develop a contingency plan to mitigate problems reaching utility agreements. For example:
		  o Identify a 'quick-response team' to address problems with the process
		  o If not already done, establish a process to quickly resolve problems with the plans or clarify requirements

Accelerate ROW acquisition Examples: • Seek accelerated ROW funding • Conduct advance ROW acquisition / Prioritize parcels for acquisition (get what's needed to start construction first) • Ensure adequate staffing • Seek willing sellers (e.g., better offers) • Provide relocation assistance to displaced tenants • Conduct accelerated environmental remediation/clearance of select parcels		
	Funding for accelerated or advance ROW	Coordinate early and often with program

Table D-5a. Project Phase: Right-of-Way (ROW)

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
	acquisition delayed or reduced	management to ensure funding is approved and available when needed

	Problems procuring critical (high-priority) parcels
	
	Example causes or issues:
	• Challenge to possession and use, condemnation, or other seller action that delays DOT ability to occupy parcels and/or increases ROW cost
	• Delays relocating tenants offsite, such as:
	  o Relocation effort larger than anticipated
	  o No suitable replacement property/facility found
	  o Legal challenge to relocation plan
	• Unanticipated contamination discovered, requiring remediation before site can be used
	• Delays demolishing structures on-site (other than from contamination issues)
	• Encounter unanticipated utilities on-site, requiring relocation before can use site
	• Other delays obtaining rights-of-entry
	• Staffing shortage (can't complete acquisition offers as planned)
		• Early on, develop a contingency plan to mitigate problems with procurement of high-priority parcels. For example:
		  o Identify a 'quick-response team' to address problems with the procurement process (e.g., see example causes at left)
		  o Establish on-call contracts with ROW specialists, relocation specialists, environmental remediation contractors, and/or demolition contractors who might be needed during acquisition process (assumes accelerated acquisition is done in advance of main construction contract)
		  o Identify additional internal staffing and have 'on-hand'

	Delays to ROW certification (agency process delay)	• Coordinate early and often with certifying authority to ensure process and requirements are understood • Identify additional internal staffing and have 'on-hand'

Table D-5b. Project Phase: Utilities

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
Accelerate utility planning and agreements Examples: • Overlap utility planning with project design and environmental activities • Coordinate early and often with design team and utility companies • Carry multiple alternatives • Provide staff to support the utility's review/approval process • Develop common/shared utility crossings • Seek accelerated utility-plan approval process		
	Late changes to the design cause delay in utility planning Example causes or issues: • Change in design late in process cascades to utility design changes (especially if utility planning and design are overlapped), resulting in delay in agreements and/or design review/approval	• Early on, develop a contingency plan to accelerate utility planning after late design changes. For example: o Develop and carry multiple alternatives early in design, to reduce impact if design changes o Coordinate early and often with utility companies o Early on, establish on-call contracts with utility specialists who might be needed later • If not already done, provide staffing support for utility companies (and plan for it early so it's ready to go when

Table D-5b. Project Phase: Utilities

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
		needed)

Table D-5b. Project Phase: Utilities

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions

	Utility agreements not reached as planned (other than from design changes)
	
	Example causes or issues:
	• Delay in review and/or approval of agreements – either by owner or utility. For example:
	  o Design/planning schedule too aggressive
	  o Inadequate staffing
	  o Utility waiting for project funding or contractor NTP
	• Disagreement over the proposed terms of the agreement. For example:
	  o Cost-sharing
	  o Scope of the utility relocation
	  o Work windows / closures
	  o Responsibility for work
	  o Questions related to the need for or legality of the planned relocation
		• Early on, develop a contingency plan to mitigate problems reaching utility agreements. For example:
		  o Identify a 'quick-response team' to address problems with the process
		  o If not already done, provide staffing support for utilities (and plan for it early so it's ready to go when needed)
		  o If not already done, establish a process to quickly resolve differences/disputes or clarify requirements
		  o Identify potential bargaining position (mitigation, design change, etc.), including securing relevant policy decisions/positions from leadership

Accelerate utility relocation Examples: • Provide incentive for utility to relocate on time • Cost sharing • Relocate critical utilities first (so can start construction)		
	Encounter and/or damage utility during construction (if owner's contractor performs the work) Example causes or issues: • Encounter previously unknown utility, perhaps	• Either internally or through contractor: Try to anticipate potential problems in advance, and then develop potential remedial measures to reduce delay if problems occur

Table D-5b. Project Phase: Utilities

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
	due to accelerated relocation schedule (e.g., utility-location effort was inadequate; 'potholing' not conducted so could accelerate schedule) • Damage existing utility even though knew it was there	• If not already done, have contractor confirm utility locations • Ensure contract provisions allow for rapid and fair resolution of these issues
	Third party does not complete agreed relocation as planned (if third party performs the work) Example causes or issues: • Third party (e.g., utility company or municipality) too busy with other work (i.e., does not prioritize this relocation effort) • Other delay to third-party design, review/approval, or sub-contracting effort • Funding delay • Third party simply "drags its feet" for other reasons	• Early on, develop a contingency plan to mitigate delays in third-party utility relocations. For example: o Identify a 'quick-response team' to address problems o If not already done, provide staffing support for utilities (and plan for it early so it's ready to go when needed) o If not already done, establish a process to quickly resolve differences/disputes or clarify requirements o Identify potential bargaining position (mitigation, design change, additional funding, etc.), including securing relevant policy decisions/positions from leadership

Table D-5c. Project Phase: Railroad

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
Accelerate railroad planning and agreements Examples: • Overlap railroad planning with project design and environmental activities • Coordinate early and often with design team and railroad representative • Carry multiple alternatives • Provide staff to support the railroad's review/approval process • Propose mitigation to speed agreements		

Table D-5c. Project Phase: Railroad

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
	Late changes to the design cause delay in railroad planning Example causes or issues: • Change in design late in process cascades to railroad-related design changes (especially if railroad planning and design are overlapped), resulting in delay in agreements and/or design review/approval	• Early on, develop a contingency plan to accelerate railroad planning after late design changes. For example: o Develop and carry multiple alternatives early in design, to reduce impact if design changes o Coordinate early and often with railroad companies o Early on, establish on-call contracts with railroad specialists who might be needed later o If not already done, provide staffing support for railroad companies (plan for it early so it's ready to go when needed)
	Railroad agreements not reached as planned (other than from design changes) Example causes or issues: • Delay in review and/or approval of agreements – either by owner or railroad. For example: o Design/planning schedule too aggressive o Inadequate staffing o Railroad company waiting for project funding or contractor NTP • Disagreement over the proposed terms of the agreement. For example: o Cost-sharing o Scope of the work to be done on, over, under, or adjacent to railroad property or at crossings	• Early on, develop a contingency plan to mitigate problems reaching railroad agreements. For example: o Identify a 'quick-response team' to address problems with the process o If not already done, provide staffing support for railroads (and plan for it early so it's ready to go when needed) o If not already done, establish a process to quickly resolve differences/disputes or clarify requirements o Identify potential bargaining position (mitigation, design change, etc.), including

Table D-5c. Project Phase: Railroad

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
	o Work windows / closures o Responsibility for work o Questions related to the need for or legality of the planned work	securing relevant policy decisions/positions from leadership

Table D-5c. Project Phase: Railroad

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
Accelerate railroad-related construction Examples: • Provide incentive for railroad to provide longer or more frequent work windows • Cost sharing • Complete critical railroad-related construction first (so can start general construction)		
	Damage railroad facility during construction (if owner's contractor performs the work) Example causes or issues: • Foul or block the track (i.e., railroad can't operate during necessary windows) • Damage railroad crossing structure (bridge) • Damage other railroad infrastructure (e.g., signals, switches, crossings)	• Either internally or through contractor: Try to anticipate potential problems in advance, and then develop potential remedial measures to solve the problems • If not already done, have contractor confirm locations of key rail infrastructure • Ensure contractor has a plan that safeguards railroad infrastructure • Ensure contract provisions allow for rapid and fair resolution of these issues

	Railroad does not complete agreed railroad-related work as planned (if railroad performs the work)
	
	Example causes or issues:
	• Railroad too busy with other work (i.e., does not prioritize this effort)
	• Other delay to railroad-driven design, review/approval, or sub-contracting effort
		• Early on, develop a contingency plan to mitigate delays in railroad-conducted work. For example:
		  o Identify a 'quick-response team' to address problems
		  o If not already done, provide staffing support for railroads (and plan for it early so it's

Table D-5c. Project Phase: Railroad

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
	• Funding delay • Railroad simply “drags its feet” for other reasons	ready to go when needed) o If not already done, establish a process to quickly resolve differences/disputes or clarify requirements o Identify potential bargaining position (mitigation, design change, additional funding, etc.), including securing relevant policy decisions/positions from leadership

Table D-6. Project Phase: Procurement and Contracting Strategy

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
Use alternative procurement method Examples: • Cost-plus-time (A+B) bidding • Cost-plus-time-plus-quality (A+B+Q) bidding • Shortlist qualified contractors and then use qualifications-based selection process • Unsolicited proposals, followed by sole source negotiations		Note that many of the same risks and risk management actions that were identified in Table 2, "Project Scoping," relative to Innovative Project Delivery methods, are applicable to this category as well. Specific attention is brought to the following actions, each of which applies to the risks discussed to the left: Examples: • Develop a procurement plan that meets the goals of the overall project and stakeholders, and in particular focus on what the goals are in using an alternative procurement and contracting approach • Ensure that the team is supported by experienced individuals (internal or consultants) • Early retention of any consultants who will be assisting agency's personnel • Secure enabling legislation early to allow alternative procurement approaches to work • Conduct outreach to the state attorney general and obtain AG opinions for statutory areas that are unclear or evolving • Conduct broad training programs on procurement and contracting innovations with staff • Conduct outreach to other DOTs that have a history of success in implementing alternative procurement and contracting programs.

Table D-6. Project Phase: Procurement and Contracting Strategy

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
		• Consider bringing key stakeholders into the training process for the implementation of the procurement approach • Outreach to public to determine where the potential statutory challenges may lie
	Litigation initiated by an interested party challenging the propriety of the alternative procurement process Example causes or issues: • Challenges to the ability of a state to select construction projects on something other than full, open competitive bidding • Challenges as to the reasonableness of the selection factors	In addition to the above: • Create a team that develops a formal procurement and contracting plan that is reasonable, logical and objective • Outreach to legislators who are concerned about alternative procurement practices • Ensure that the Attorney General's office is cognizant of potential issues and prepared to act quickly to address any challenges
	Public concern (and political pressure) resulting from the use of procurement processes that heavily weight non-price factors Example causes or issues: • Perceived conflict of interest when a design-builder is first selected to perform preliminary engineering and then has sole source negotiation rights for final design and construction • Perception that contracts awarded on qualifications basis are "sweetheart" contracts and the result of cronyism.	In addition to the above: • Outreach to the public to make the procurement process transparent and to explain the rationale and public benefit behind the procurement choice • Use of independent outside consultants to evaluate pricing of the contracting teams • Use of escrowed bid documents to obtain access to the documents • Use open book negotiation process • Require contractor (design-builder) to certify the currency, completeness and accuracy of its open book submissions • Consider, where applicable, the use of

Table D-6. Project Phase: Procurement and Contracting Strategy

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
		construction management at risk contracting principles, where the bulk of the work is competitively subcontracted to third parties, and with prime contractor being responsible to manage such work and interfaces.
	Public reaction to procurements that trade-off early accelerated completion with full road closures	In addition to the above: • Developing a comprehensive outreach program to explain the benefits of this system • Determining and widely disseminating maintenance of traffic plans that minimize disruption
	Limited competition arising from projects perceived as being created for large contractors	In addition to the above: • Assess whether the project can be broken down into alternative contract packaging (see below) • Require proposers to submit a subcontracting plan that demonstrates how it will use small businesses and have this as a significant selection factor
	Other problems procuring contract Example causes or issues: • Bid protest • Unclear contract documents or language resulting in claims, whether credible or not. This could be a problem during contract procurement, during construction, or both. • Contractor default (most likely during construction)	In addition to the above: • Pre-qualify contractors • Short-list a minimum of three contractors • Ask contractors' association to provide feedback on draft contract documents (e.g., Request for Proposal) • Set reasonable minimum bonding requirements
Use alternative contract	See above	In addition to the above:

Table D-6. Project Phase: Procurement and Contracting Strategy

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
packaging Examples: • Larger number of smaller contracts • Use of allowances for work that is not sufficiently designed at the time of bid or is to be undertaken far in the future and that will be performed by smaller contractors		• Conduct a thorough evaluation as to the goals and detriments of alternative contract packaging • Develop an outreach program for the smaller contractors and DBEs • Consider lessons learned from other agencies that have used allowance-type of contracting arrangements
Employ advance procurement Examples: • Early procurement of long-lead items • Advance earthwork / embankment construction contracts • Advance remediation of contaminated sites		In addition to the above: • Ensuring that the project delivery, procurement and risk management plans are fully aligned • Integrating early procurement of components into a qualifications-based selection process for the prime contractor
	Expending funds in advance of full procurement	See above, particularly as it relates to understanding how the plans integrate
Use delayed-start provision in contract Examples: • Purchase of construction ROW to allow for prefabrication of elements • Allow contractor to revise designs prior to beginning work to minimize traffic impact	**Perception of delayed start will erode internal or external confidence in rapid renewal goals**	In addition to the above: • Educate stakeholders in need for delayed start • Align incentives and disincentives with start of mainline work rather than start of contract

Table D-6. Project Phase: Procurement and Contracting Strategy

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
• Allow contractor to do off-line work that will not impede traffic		
	Mobilization costs are higher and at risk if contractor defaults	In addition to the above: • Use best-value procurement to ensure that a solvent and experienced contractor is selected • Monitor work and payment closely

Table D- 7. Project Phase: Operations and Maintenance (O&M)

Rapid-Renewal Strategy	Related Risk or Opportunity Categories	Potential Risk-Management Actions
Consider private O&M Contractor		
	Required O&M effort greater than planned (either more frequently, more extensive, or both) Example causes or issues: • Quality of constructed facility not as anticipated or required • Extreme seasonal weather impacts • Traffic demand greater than anticipated, or mix of vehicle types not as anticipated	• Ensure adequate contractual provisions (e.g., warranty) in contract with constructor • Ensure adequate quality control and assurance during construction of facility (to minimize risk of poorly-constructed facility) • Conduct uncertainty-based traffic modeling for project's projected lifetime
	O&M contractor does not perform per contract Example causes or issues: • Performs O&M tasks when required, but not to technical standards • Fails to perform O&M tasks per requirements (regardless of how specified)	• Ensure adequate contractual provisions (e.g., performance bond) in contract with O&M contractor • Develop contingency plan in advance to quickly mobilize agency O&M resources if needed

Table D-8. Project Phase: Replacement

Rapid-Renewal Category	Related Risk or Opportunity Categories	Potential Risk-Management Actions
	Replacement required sooner than planned Example causes or issues: • Demand increases faster than anticipated, requiring additional capacity • Poor design, materials, and/or construction quality	• Conduct uncertainty-based demand modeling during design (consider uncertainties and risks that could affect modeling results) • Ensure adequate contractual provisions (e.g., warranty) in contract with constructor • Ensure adequate quality control and assurance during construction of facility (to minimize risk of poorly-constructed facility) • Delay replacement with additional maintenance (develop contingency plan in advance for funding and resources)
	Replacement does not perform as intended (e.g., inadequate capacity; poor construction)	

ATTACHMENT C. UNMITIGATED RISK REGISTER (without risk assessments)

The Risk Register for the project (as described in Attachments A and B) was developed (by consensus) by a facilitated group of project team and project-independent subject matter experts, as follows:

- Risks were first brainstormed and then categorized, edited, and added to create a comprehensive and non-overlapping set (see Table C-2 for the resulting set, and see the template in Attachment I for initial steps). As previously noted, only performance (and thus risks) through construction has been focused on for now.
- The factors that define risks (i.e., impacts and probability of occurrence) before any additional mitigation ("unmitigated") were then assessed for each of the risks in terms of mean value/ratings (see Table C-1 for rating "scale" definitions for assessments, and Table C-2 for the assessments for each risk, and see the template in Attachment I for a summary of those assessments)

Table C-2. Unmitigated Risk Register for Mean-Value / Rating Assessment (see Table C-1 for rating scale definitions; for risks through construction only)

Item	Risk or Opportunity				
	Planning				
PL1 Excluded	**Project funding delayed or reduced** The project is currently funded for an amount that QDOT feels is adequate. However, if additional funding is required (i.e., if costs increase for various reasons), might be a delay in obtaining the additional funding. However, QDOT's objective is to evaluate the project's risk assuming funding is available without delay. Hence, QDOT wants to *exclude* uncertainty in funding at this time (but might later treat that uncertainty by defining separate "model scenarios" to evaluate the impact of various potential funding delays). Otherwise, *exclude* the risk that funding is cancelled or substantially reduced (so that scope reduction is required, which would lead to a "different" project).				
PL2	**Opposition to removing access to US 555 from 12th Street** Several businesses rely on this access and might protest or challenge the removal of the access. However, removal of that access is necessary for the project. Hence, this design decision is unlikely to be reversed. However, some mitigation might be required as compensation.				
PL3 Elsewhere	**Opposition to "splitting" alignment of SH 111 in the interchange area** The City does not like this alternative. This issue is captured as a factor influencing the probability that this split will occur – see risk D2.				
PL4 Minor	**Other stakeholder issues not captured separately**				

Item	Risk or Opportunity				
	Scoping				
SC1 Minor	**Change in East-West project limits** Project might be required (either for political or operational reasons) to improve longer or shorter stretch of US 555 than assumed in the base estimate. The project team and QDOT believe this is unlikely because funding is not available for such a significant change, and the need is not clear (for the project to perform as desired).				
S2C Minor	**Change in North-South project limits** Project might be required (either for political or operational reasons) to improve longer or shorter stretch of SH 111 than assumed in the base estimate. Similar to discussion for S1.				
SC3	**Additional local improvements required** For example: • More improvements on Main Street away from US 555 • More improvements on North and/or South Avenues away from SH 111 • More improvements on West and/or East Streets away from US 555 Schedule impacts are design-related.				
SC4 Minor	**Increased aesthetics for US 555 / SH 111 interchange** For example, “gateway” appearance, decorative lighting, etc. The project already includes reasonable aesthetics, and a significant ‘gateway’ theme is well outside the project’s budget. The City would therefore have to pay for such improvements, which it is unlikely to be able to afford.				
SC5	**Replace culvert over Wandering Creek**				

Item	Risk or Opportunity				
	Base assumes that the state fisheries agency will allow widening this culvert, especially since no listed fish species are believed to live this far up Wandering Creek. The fisheries agency has, however, required replacement of similar culverts on nearby projects.				
SC6	**Provide new lighting throughout project** Base assumes new lighting only in the interchange area. The team increasingly believes that new lighting will be required throughout (mainly because they will have to relocate existing lighting to widen the roadway anyway).				
SC7 Minor	**ITS added to this project** Unlikely – not funded and the system-wide ITS development is lagging this project.				
	Preliminary Design and Environmental Process <u>For all relevant risks in this category, the following conditions apply</u>: Each risk includes all related / correlated design, environmental, right-of-way, and construction impacts. Impacts shown are in addition to any assessed base uncertainties.				
PD1	**Shift alignment of US 555 at east end of project** This would reduce wetland impacts by shifting alignment to the south. However, there is some resistance (City) to shifting the alignment this way because of the number of business displacements it would cause. It could also cause a problem with geometry at the intersection of East Street. The group therefore thinks that this is unlikely to occur. If it did, however, the impacts would include reduced wetland impacts, increased right-of-way costs (mostly due to additional demolition and business relocations), additional design time. The change in construction cost would be minimal.				
PD2 Minor	**Split alignment of SH 111 at US 555 interchange**				

Item	Risk or Opportunity				
	Instead of widening on existing alignment; would allow for more rapid construction but requires additional ROW. Benefits (reduced construction duration) probably don't outweigh the detriments (additional ROW; less efficient traffic flow; re-design). The City and at least two public groups do not like this alternative. Therefore, it is unlikely to occur.				
PD3	**Change in configuration of SH 111 / US 555 interchange** QDOT's preliminary design (SPUI) is one of several viable alternatives, and it is expected that the contractor could propose a suitable alternative. It is uncertain how much such a change might cost relative to the currently-assumed alternative (could be more, could be less), but QDOT won't accept a design that is significantly more expensive. Includes potential change in structure and foundation type/size, but assumes that an appropriate accelerated bridge construction technique will be used.				
PD4	**Ground improvement required in interchange area** QDOT HQ design is also concerned that a recent change to the seismic design criteria (which is still being evaluated) might require localized ground improvement to mitigate for liquefaction potential. The project team thinks this is unlikely, but could have significant impacts if it occurs.				
PD5	**Shoulders required on US 555** For example, if FHWA or QDOT HQ Design both don't approve the no-shoulder exception/deviation. The project team is reasonably confident that this design exception will be approved based on recent, similar approvals for other nearby projects. However, if shoulders are required, the impacts are significant: additional right-of-way would be required, construction costs would increase, the				

Item	Risk or Opportunity				
	draft EA might have to be modified (wetland impacts would increase), and design time (prior to RFP) would increase.				
PD6	**Shoulders required on SH 111** For example, if QDOT HQ Design doesn't approve the no-shoulder exception/deviation. Similar to the discussion and assessments for risk D5. For the quantitative risk analysis: Risk D6 is correlated to risk D5. If risk D5 does not occur (shoulders not required on US 555), then it is likely that shoulders won't be required on this facility either. If risk D5 does occur, then shoulders will likely be required for SH 111 as well.				
PD7 Minor	**Additional cost for signalized intersections** Excludes any change in the number of intersections that is captured separately in risks related to project limits (i.e., risks S1 and S2).				
PD8	**Change in pavement section and/or type** The base assumes concrete pavement to provide longevity (one of the project's goals). QDOT is therefore most likely to specify a concrete pavement. Asphalt pavement might be selected to provide compatibility with existing pavement (beyond the project limits) and to save initial cost. However, QDOT considers maximizing longevity (including life-cycle costs) a higher priority than saving initial capital cost.				

Item	Risk or Opportunity				
PD9 Minor	**Rehabilitate instead of reconstruct existing roadway (e.g., overlay instead)** See *Guide* Appendix C, Appendix D, or Table D-4f. Existing roadway is 20 years old; might not be cost effective to rehabilitate when have to build new lanes anyway. In addition, rehab is not as likely to meet the project objective of maximizing longevity of the facility. Note: for the quantitative risk analysis, this risk is correlated to risk D8 (impacts are a function of the outcome of that risk).				
PD10 Minor	**Change in stormwater design standards** The design incorporates the latest standards, which are only two years old. Hence, it is unlikely that new standards will emerge in this project's timeframe.				
PD11	**Cannot use City sewer system for project runoff (or City charges for use)** The City might deny use or charge QDOT for various upgrades to the system to accommodate stormwater runoff from this project. The project team and QDOT management are "almost certain" that the City will ultimately allow use of the City's system (the City needs this project, and the additional load on the sewer system is not substantial), but will most likely ask for money to help upgrade its system. QDOT would probably capitulate as this is the best option from a cost and time perspective. This cost would occur during the project's "utility relocations" phase. This issue is correlated with the likely request by the City to help pay for a water and sewer-line relocation (see risk U2 under utilities risks). For the quantitative risk analysis, the group assesses that if risk U2 occurs (i.e., QDOT decides to help pay for relocation), then this risk is much less likely to occur.				
PD12	**Structures impacted by Main Street realignment are eligible for**				

Item	Risk or Opportunity				
	Historic Register Can reasonably capture the range of credible possibilities with the following set of potential (mutually-exclusive) scenarios / outcomes: A. Not historic structures (base assumption) B. Historic structures, but no significant impact to project cost or schedule (e.g., document, then acquire) C. Historic structures, creating significant impact to project cost or schedule (e.g., have to relocate structures; structures are contaminated; or have to shift project alignment to avoid)				
PD13	**Change in environmental documentation** Only treat this issue here if not captured separately by specific triggers / issues elsewhere (e.g., design changes). Base assumes an EA, but an EIS might be required if impacts are greater than assumed. Can reasonably capture the range of credible possibilities with the following set of potential (mutually-exclusive) scenarios / outcomes: A. Complete EA as planned (base assumption) B. Complete EA with additional effort, but with no significant changes to the project C. EIS required, but with no significant changes to the project **D.** EIS required, resulting in significant change to the project design, right-of-way, and/or construction				
PD14	**Delays completing environmental documentation** From various causes if not already captured separately (i.e., significant design changes; change in type of environmental documentation, risk E2). For example: • Additional impacts identified • Process delays (internal or external reviews, comments, and/or approvals)				
PD15	**Encounter unanticipated contamination in interchange area**				

Item	Risk or Opportunity				
	If encountered, likely to be hydrocarbon-based soil and/or groundwater contamination.				
PD16	**Additional wetland mitigation required for planned alignment** Additional mitigation could be required for various reasons. For example: • Change in mitigation requirements (ratios, buffers) • Change in wetland classification • Impacts different than assumed (i.e., underestimated originally) (this could happen for the current or shifted alignment) Note: for the quantitative risk analysis, this risk is partially a function of any potential shift in alignment at the east end of the project (risk D1). If risk D1 occurs and the 'base' wetland impacts are reduced, the probability of this risk is reduced.				
	Environmental Permits				
EP1 Minor	**Challenge to environmental determination or permits** For any reason not captured elsewhere. Could come from organized public groups for various reasons. However, very unlikely for the base project (chances could increase for some alternatives like shifting the alignment at the east end of the project, but these impacts are captured in those risks).				
EP2	**Delay obtaining the 404 permit** Either from internal or USACE process delays (review, approval) or deficiencies in QDOT's application. Note that this risk is assumed to be approximately independent of risks D1 and E6 (delay issues could occur regardless of the outcomes from those risks).				

Item	Risk or Opportunity				
	Right-of-Way				
RU1	**Uncertainty in ROW inflation rate** Regionally; before considering the localized effects of accelerating development, which is captured separately. Despite a sag in the economy, property prices have held steady, and appear to even be increasing slightly. However, this could change (e.g., if this area is lagging the economy). Over the short term of this project, local indicators and the ROW professionals anticipate an average increase of approximately 3%/year in the area.				
RU2	**Accelerating pace of development in interchange area** Beyond the regional ROW inflation rate captured in R1. Several new developments are planned in the area, and at least one could be implemented before this project is let. The impact to this project would be increased acquisition and perhaps relocation costs compared to what is currently assumed in the estimate.				
RU3	**Unwilling sellers** Note: base cost excludes condemnation costs/allowance. This risk is separate from risk R2. Particularly in the US 555 / SH 111 interchange area, property owners might not want to relocate, leading to increased cost to acquire ROW (e.g., have to go through condemnation). Note that condemnation does not normally extend the right-of-way acquisition timeframe, because QDOT can usually quickly gain possession-and-use of condemned properties.				

Item	Risk or Opportunity				
RU4 In R2	**Additional relocation or demolition required** Excludes additional relocation or demolition that might be required to accommodate changes in design or scope, which are captured as part of those separate risks. Excludes contamination, which is captured separately. For example, multi-tenant properties could be complex to relocate. The group assesses that this potential additional cost and time was captured in risk R2.				
RU5 Minor	**Additional ROW required for planned project** Excludes additional ROW that might be required for changes in design or scope, which are captured as part of those separate risks. For example, initial estimates for required ROW for the assumed design were incorrect or incomplete. The group assesses that the potential significant changes were captured as part of other risks.				
RU6	**Other delays to ROW planning** For reasons not captured as part of other specific risks. For example, late changes in design result in changes in ROW plans, or internal QDOT delays to ROW plan development.				
	Utilities				
RU7	**Telecom utility wants a cost-sharing agreement** The Telecom's presence in the project right-of-way pre-dates QDOT's, so QDOT cannot force relocation. The Telecom just recently replaced its fiber optic backbone, so not likely to replace without some sort of cost sharing (or, at least, replace within the timeframe needed by this project).				

Item	Risk or Opportunity				
RU8	**QDOT helps City pay for water and sewer-line relocation** See *Guide* Appendix C (rapid renewal strategies / methods). To help maintain project schedule, QDOT might help pay for the sewer-line relocation. This "risk" is therefore really a project / policy decision within QDOT's control. This decision comes at a monetary cost but avoids schedule delay (as reflected to the right). Note that for the quantitative risk analysis, the outcome of this risk affects the likelihood of occurrence for risk PD11.				
RU9 Minor	**Other utility relocations not completed on time** For issues not captured separately in other risks. For various reasons, including delayed negotiations, design, or relocation work itself.				
RU10 Minor	**Damage existing utility or encounter unanticipated utility during construction** Possible, but the time impacts are quickly mitigated. The cost impact would be the D/B contractor's responsibility.				
	Contracting and Procurement				
CP1	**Uncertainty in construction-cost inflation rate** Excludes contracting market conditions and material-supply issues, which are captured separately in risks CP2 and CP3. This issue includes uncertainty in the general regional and national trends in construction-industry cost changes over time (general inflation), with reasonable adjustment for this region.				
CP2	**Uncertain Design/Build contracting market conditions at time of bid** See *Guide*, Appendix D-2 or Table D-6. Separate from general construction inflation and material-supply issues,				

Item	Risk or Opportunity				
	which are captured in risks CP1 and CP3, respectively. This issue includes uncertainty in pricing strategy and other contractor competition factors. QDOT expects four proposals/bids, which could improve competition. However, recent experience for similar projects is that bids are coming in above QDOT's Engineer's Estimates. Can reasonably capture the range of credible possibilities with the following set of potential (mutually-exclusive) scenarios / outcomes: A. Market conditions are favorable (competitive), and bids come in below the base estimate B. Market conditions are similar to assumed in the estimate (minimal change from base) C. Market conditions are not competitive, so bids are higher than the base but still acceptable (below threshold for canceling the procurement) D. Market is not competitive, and no acceptable bids are received – requires re-bidding and perhaps repackaging to get acceptable bids.				
CP3 Elsewhere	**Material-supply issues** Various local factors could affect the availability of materials for this project. For example: • Cannot locate an appropriate fill source • Fill source is farther away than assumed • Aggregate prices higher than anticipated • Steel prices higher than anticipated • Cement prices higher than anticipated The group believes that all of these issues are captured in either risk CP1 or CP2.				
CP4 Minor	**Change in project delivery method**				

Item	Risk or Opportunity				
	See *Guide* Appendix D-2 or Table 4-6. Contract other than through the assumed single Design/Build contract. Only treat here if not already captured under the market conditions risk (CP2). It is unlikely that QDOT will change to a traditional delivery method (e.g., Design/Bid/Build) given the rapid renewal-type objectives for this project. Other delivery alternatives are unlikely, either because enabling legislation does not exist or QDOT does not have adequate experience with those delivery methods.				
CP5 Minor	**Accelerate pre-construction activities to reach NTP sooner** See *Guide* Appendix C, Appendix D-2 or Table D-3. If not captured separately under Design, Environmental, and/or ROW risk categories. To reach NTP more quickly, QDOT could adopt a more-aggressive pre-construction strategy. For example: • Moving to NTP before permitting is complete. • Could seek streamlined environmental process or design-approval process (see *Guide*, Appendix D-2 or Table D-3). However, it might be too late to implement these for this project (would have been better to plan for this in advance of starting work on the project). The group believes that a more-aggressive permitting vs. NTP strategy is possible, but introduces its own risks (i.e., if NTP is issued before the environmental permits are complete, the contractor could have grounds for significant claims if permit conditions change relative to the RFP). Hence, it is unlikely for QDOT to pursue this strategy.				
CP6	**Use incentives to accelerate D/B construction**				

Item	Risk or Opportunity				
Minor	See *Guide*, Appendix D-2 or Tables D-2 and D-6. The team believes that QDOT is unlikely to apply additional incentives – use of D/B delivery method and performance-based specs should provide adequate flexibility and incentive for the contractor to complete the project within QDOT's desired timeframe.				
CP7	**Issues with D/B design or submittals** For example: • Internal QDOT or FHWA delays reviewing and approving submissions • Errors or omissions in D/B submissions				
CP8	**Other problems with D/B contract procurement** See *Guide*, Appendix D-2 or Tables D-2 and D-6. Aside from issues captured separately (e.g., as part of market conditions risk). Note: project-cancelling issues are excluded; most of the remaining identified issues were assessed to be low likelihood and relatively low impact for this project. Hence, the group combined them into one 'larger' issue and assessed their combined potential impacts. Even so, the group believes that a significant problem is unlikely (especially given QDOT's reasonable history for such procurements). If something did occur, the most-likely impact to schedule would be during D/B procurement. For example: • Bid protest (pre-award or post-award) • Unclear contract documents • Contractor default				

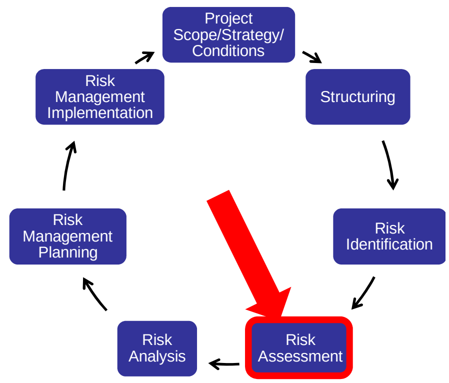
Item	Risk or Opportunity				
	• Bonding or insurance issues • QDOT unfamiliarity with D/B contracting • Approach to specifications (e.g., performance-based specs)				
	Construction				
CN1	**D/B construction phasing significantly different than assumed** Excludes specific changes to schedule and phasing related to changes in design, etc. that are captured under other risks. The base schedule is not believed to be overly optimistic or aggressive. It's impossible to know at this point how the D/B will actually construct the project, so the actual schedule and phasing could be significantly different than currently assumed.				
CN2	**Additional Maintenance of Traffic required** See *Guide*, Appendix D-2 or Table D-4g. Either because the original plan doesn't work and needs to be modified, or the plan works but simply needs to be augmented.				
CN3	**Problems with planned accelerated bridge construction (ABC) technique** QDOT assumes the contractor will employ ABC (regardless of the structure type selected for the interchange; hence, this issue is approximately independent of risk D3). The performance of this planned rapid renewal method (accelerated bridge construction) is difficult to predict because the method the contractor will use is not known, and many ABC techniques are still evolving. Potential problems include (see *Guide*, Appendix D-2 or Table D-4b): • Selected technology doesn't work as planned (technical issue) • Delays procuring technology *Note that this risk does not apply if the SH 111 alignment is split at the*				

Item	Risk or Opportunity				
	interchange (construction is out of traffic; ABC is not employed).				
CN4	**Unable to construct interchange embankments as rapidly as assumed** Base assumes rapid construction techniques for the approach embankments of the SH 111 overcrossing at the interchange with US 555. The performance of this planned rapid renewal method (rapid embankment construction) is difficult to predict for the following reasons (see *Guide*, Appendix D-2 or Table D-4c): • Uncertainty in subsurface conditions (soft soils are suspected); • Uncertainty in what method the contractor will choose; and • Uncertainty in performance of the selected method for actual subsurface conditions (e.g., method doesn't perform as intended). It is therefore unclear at this point how much benefit will be achieved relative to traditional embankment construction. If the method doesn't work, remedial measures will be needed to accelerate embankment construction, but with some loss of time.				
CN5	**Difficult foundation installation** Separate from ground-improvement issues. Information is limited in the interchange area (additional geotechnical investigation is scheduled for later). However, anecdotal information indicates that near-surface ground conditions are poor enough to require deep foundations (assumed in the base). Could encounter obstructions, have difficulty obtaining design capacity for various reasons, etc.				
CN6 Minor	**Severe weather event significantly impacts construction** This refers to specific, individual events, like earthquake or flood, during construction. Could result in either delay or significant damage. Very low				

Item	Risk or Opportunity				
	likelihood of significant impact in this geographic location.				
CN7	**Colder-than-usual winter** Usually, construction work can proceed year-round in some manner (the base schedule accounts for this). However, an extreme winter could result in perhaps a one-month delay.				
CN8 Minor	**Significant accident during construction** Low likelihood. If occurs, time impact is likely to be minimal and cost impacts could be covered by D/B insurance.				
CN9	**Limited construction staging area in vicinity of interchange** Either QDOT or the contractor will likely have to find a suitable staging area, but it might not be close to the interchange, which could increase contractor costs.				
CN10 Minor	**Fish window in Wandering Creek** Currently, no listed species are believed to inhabit Wandering Creek near US 555. Hence, in-water work windows are assumed to not apply. Even if a window did apply, however, the contractor should easily be able to stage culvert work to accommodate a window.				
CN11 Minor	**Non-compliance with permits during construction** Low likelihood of any significant non-compliance. Even if it does occur, low likelihood of significant cost impact (contractor's) or schedule impact (QDOT's schedule, but contractor financially responsible).				
CN12	**Extended overheads as a function of project delays** Pre-construction (QDOT staff): $100k / month of delay Construction: • QDOT staff: $100k / month of delay • Contractor: For compensable delays, $250k / month of delay (modeled as $125k / month of total delay, assuming 50% of delays				

Item	Risk or Opportunity				
	are compensable)				
	Minor and Unidentified Risks and Opportunities Aggregate effect of items labeled "Minor" above. "Major" means the items quantified above (i.e., all items other than those labeled "Minor" above)				
	Aggregate Minor Risks				
	Aggregate Minor Opportunities				
	Unidentified Risks				
	Unidentified Opportunities				

Module 6:
Risk Assessment



6-1

Risk Assessment

- **Learning Outcomes**
- Risk Assessment Methods
- Assessing Risk Factors
- QDOT Case Study
- Summary

6-2

Learning Outcomes

- Determine severity value of each identified risk or opportunity using mean-value method
- Rank identified risks and opportunities based on project impact

6-3

Risk Assessment

- Learning Outcomes
- **Risk Assessment Methods**
- Assessing Risk Factors
- QDOT Case Study
- Summary

6-4

Risk Assessment

The primary objectives of risk assessment are:

- Determine the significance of each risk and opportunity
- Determine those risks and opportunities that should be refined further (e.g., by gathering additional information) or reduced/exploited (if possible) through proactive risk management actions

6-5

Risk Assessment – Probability of Occurrence Refresher

Event	Probability
Death and taxes (happens to everyone, eventually)	100% (certain)
100-year storm is exceeded during its return period T=100 years	63.4%
Heads on a toss of a fair coin	50%
Two heads on two coin tosses	25%
Roll a "6" on a single, fair, six-sided die	16.7%
Four heads on four coin tosses	6.25%
100-year storm (or larger) will occur in a particular year	1%
Impossible (event absolutely cannot occur)	0% (certain)

6-6

Available Methods - Qualitative

- Red/Yellow/Green
  - Qualitative ratings for risk factors, which generally are not defined and are combined subjectively
- Rating Scale
  - Uses numerical ratings, which generally are neither appropriately defined nor appropriately combined

6-7

Available Methods - Quantitative

Risk Characterization:

- Ratings
  - Numerical scales (e.g., a High likelihood of occurrence might be defined as a probability of occurrence between 40% and 70%)
- Numerical Values
  - A risk might be assessed to have a 25% probability of occurring, and if it occurs, would result in a mean value of $1 million additional cost

6-8

Available Methods - Quantitative

Among many available methods:

- **Mean-value method (quantitative)**
  - **Ratings**
  - **Values**
- Full uncertainty analysis (Module 9)

6-9

Mean-Value Method

- Pros
  - Quick (especially for ratings) and unambiguous
  - If done properly ➔ quick and absolute severity value for each risk (for ranking)
  - If set of risks is comprehensive and non-overlapping, can combine risks ➔ total project risk
  - Forms basis for probabilistic (full quantitative) risk management
- Cons
  - Apply carefully (especially to determine collective risk)

6-10

Mean-value Method

A. ***Mean Ratings*** - per pre-defined ranges (e.g., H, M, L)

1. Define risk likelihood and impact value ranges (e.g., H, M, L)
2. Assess each risk for likelihood and impact (cost, schedule, disruption)
3. Determine "severity" rating for each risk

B. ***Mean Values*** - skip ratings

1. Assess mean value of each likelihood and impact (e.g., $)
2. Determine mean "severity" value for each risk

A. Mean-Value Method - **Ratings**

1. Define risk likelihood and impact value ranges

COST CHANGE

Adjectival Rating	Percent of Base Cost		Absolute Value (CY $M)		Expected Mean Value	
	Low	High	Low	High	Percent	Absolute
VH	24.94	49.88	4.00	8.00	37.41	6.00
H	9.98	24.94	1.60	4.00	17.46	2.80
M	3.12	9.98	0.50	1.60	6.55	1.05
L	1.25	3.12	0.20	0.50	2.18	0.35
VL	0.00	1.25	0.00	0.20	0.62	0.10

DURATION CHANGE

Adjectival Rating	Percent of Base Schedule		Absolute Value (months)		Expected Mean Value	
	Low	High	Low	High	Percent	Absolute
VH	34.29	68.57	12.00	24.00	51.43	18.00
H	11.43	34.29	4.00	12.00	22.86	8.00
M	2.86	11.43	1.00	4.00	7.14	2.50
L	0.71	2.86	0.25	1.00	1.79	0.63
VL	0.00	0.71	0.00	0.25	0.36	0.13

A. Mean-Value Method – **Ratings**

1. Define risk likelihood and impact value ranges

DISRUPTION CHANGE

Adjectival Rating	Percent of Base Disruption		Absolute Value (M person-Hrs)		Expected Mean Value	
	Low	High	Low	High	Percent	Absolute
VH	28.57	57.14	0.20	0.40	42.86	0.30
H	14.29	28.57	0.10	0.20	21.43	0.15
M	0.00	14.29	0.00	0.10	7.14	0.05
L	0.00	0.00	0.00	0.00	0.00	0.00
VL	0.00	0.00	0.00	0.00	0.00	0.00

PROBABILITY OF OCCURRENCE

Adjectival Rating		Probability Range	Mean Probability
	Low	High	
VH	0.70	1.00	0.85
H	0.40	0.70	0.55
M	0.20	0.40	0.30
L	0.05	0.20	0.13
VL	0.00	0.05	0.03

6-13

A. Mean-Value Method - **Ratings**

1. Assess each risk for likelihood and impact
2. Template determines "severity" rating for each risk

Risk #	Risk	Impact Rating			Probability Rating	Mean Severity Rating (equivalent cost in inflated $M)
		Cost	Schedule	Disruption		
C1	D/B Design & Construction Risk Contingency, Escalation & Profit	H	L	VL	VH	VH
C2	Bidding Climate for NATM Tunnel	M	VL	VL	H	H
C3	Construction Materials Escalation	M	VL	VL	L	L

Mean Severity rating is translated to numerical value (e.g. if VH=0.70 to 1.0 then value=0.85)

6-14

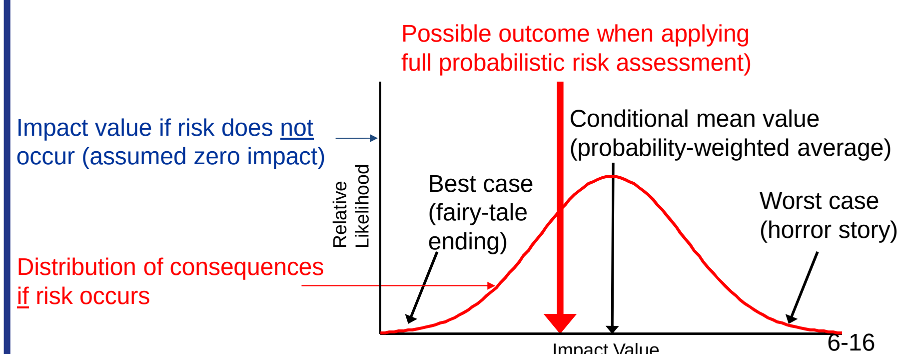
B. Mean-Value Method - **Values**

1. Assess mean value for each risk likelihood and impact
2. For each risk, the template combines risk likelihood and impact value into a mean severity value
3. Template prioritize risks per their mean severity values

Risk #	Risk	Mean Consequences If Risk Occurs: Mean Cost (uninflated $M)	Mean Delay to Overall Schedule (months)	Mean Disruption (user lost-hours)	Probability of Occurrence	Mean Severity (in Equivalent cost, Inflated $M) (escalation=10%, 1mo delay=$6M)
C1	D/B Design & Construction Risk Contingency, Escalation & Profit	75	1	0	80%	70.8
C2	Bidding Climate for NATM Tunnel	20	0.5	0	50%	12.5
C3	Construction Materials Escalation	12	0.5	0	10%	1.6

Assessing Risk Factors – Mean Consequences of Occurrence

- Represents central tendency of all possible outcomes



Risk Assessment

- Learning Outcomes
- Risk Assessment Methods
- **Assessing Risk Factors**
- QDOT Case Study
- Summary

6-17

Assessing Risk Factors

- Use relevant historical information
- Adequate "data" set does not usually exist
- Rely on "subjective assessment" of expert opinion/judgment (including experience)
  - Widely accepted (e.g., NRC, EPA, DOE, DOD)
  - Best available approach

6-18

Assessing Risk Factors– Avoiding Bias

- Ensure accurate, defensible assessments
- Avoid common pitfalls:
  - Poor problem structure (e.g., ambiguous)
  - Adverse group interactions (e.g., dominance)
  - Individual or group biases:
    - *Cognitive biases* – beliefs are inconsistent with information (e.g., optimistic)
    - *Motivational biases* – statements are inconsistent with beliefs (e.g., exclusions)
  - Ignoring important relationships among factors
  - Missing some possibilities/information

6-19

Risk Assessment

- Learning Objectives
- Risk Assessment Methods
- Assessing Risk Factors
- **QDOT Case Study**
- Summary

6-20

QDOT Case Study for Risk Assessment

In groups of 4-5 people:

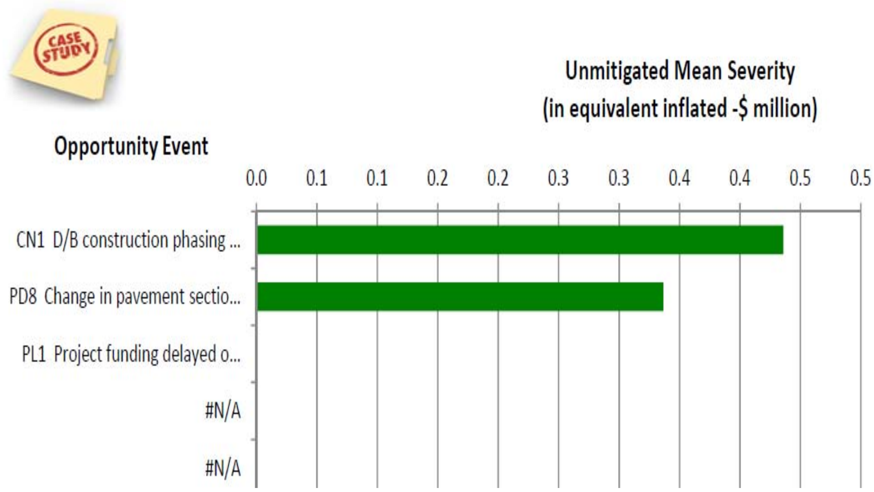
- Select “facilitator”
- Select template input person
- Review Risk Scaling Table (Table C-1 at the end of Module 6)
- Review identified risks in Module 5 Exercise
- Assess probability and impact for risks in assigned categories using the “unmitigated risk assessment” (Step 4 in template)
- Share severity results with participants (verbally)

6-21

QDOT Unmitigated Risk Ranking Plots-Risks (Tornado Chart)

6-22

QDOT Unmitigated Risk Ranking Plots-Opportunities (Tornado Chart)



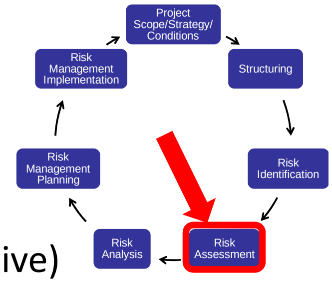
6-23

Risk Assessment

- Learning Outcomes
- Risk Assessment Methods
- Assessing Risk Factors
- QDOT Case Study
- **Summary**

6-24

Summary



- Risk assessment for:
  - Severity of project risks and opportunities
- Mean-value method (quantitative)
  - Ratings (defined value ranges) → L, M, H
  - Values → $, months

6-25

Questions?

goSHRP2@dot.gov

SHRP2 SOLUTIONS

Save lives. Save money. Save time.

6-26

Unmitigated Risk Factor Assessment

Item	Risk or Opportunity (from Risk Register by item#) (add rows as needed)	Assessed Probability of Occurrence (0 to 1, <u>or</u> rating*)	Assessed Impacts (<u>if</u> occur) (*ratings as defined by range categories –defaults shown) Mean Direct Cost Change $ to Activity (uninflated $M, <u>or</u> rating*)	Activity $ Affected (circle)	Mean Duration Change T to Activity (months, <u>or</u> rating*)	Activity T Affected (circle)	Mean Disruption Change D to Activity (M man-hrs, <u>or</u> rating*)	Activity D Affected (circle)	Calculated[1] Severity (equivalent inflated $M, <u>or</u> rating*)	Rank
EXAMPLE (showing mean values and ratings) Note: [1]*Considers extended OHs, inflation, and values of schedule and disruption* [2] Pr Dsn/Env Pr = preliminary design and environmental process										
RUi	Landowner(s) unwilling to sell parcel <xxx>	*0.5* VH (0.7 to 1.0) H (0.4 to 0.7) M (0.2 to 0.4) L (0.05 to 0.2) VL (0.0 to 0.05)	*+$0.5M* + – VH (>25%) + – H (10% to 25%) + - M (3% to 10%) + - L (1% to 3%) + - VL (<1%) 0	Planning Scoping Pr Dsn/Env Pr[2] Enviro Permits ROW/Util/RR Final Design Procurement Construction Operations Replacement Funding 1,2,3	*+2 mo* + – VH (>1 yr) + – H (4 mo to 1 yr) + - M (1 mo to 4 mo) + - L (1 wk to 1 mo) + - VL (<1 wk) 0	Planning Scoping Pr Dsn/Env Pr[2] Enviro Permits ROW/Util/RR Final Design Procurement Construction Operations Replacement Funding 1,2,3	*0 M man-hrs* + – VH (>25%) + – H (10% to 25%) + - M (3% to 10%) + - L (1% to 3%) + - VL (<1%) 0	Planning Scoping Pr Dsn/Env Pr[2] Enviro Permits ROW/Util/RR Final Design Procurement Construction Operations Replacement Funding 1,2,3	*+$0.3M* + – VH (>25%) + – H (10% to 25%) + - M (3% to 10%) + - L (1% to 3%) + - VL (<1%)	*1*
		VH (0.7 to 1.0) H (0.4 to 0.7) M (0.2 to 0.4) L (0.05 to 0.2) VL (0.0 to 0.05)	$ M + – VH (>25%) + – H (10% to 25%) + - M (3% to 10%) + - L (1% to 3%) + - VL (<1%) 0	Planning Scoping Pr Dsn/Env Pr[2] Enviro Permits ROW/Util/RR Final Design Procurement Construction Operations Replacement Funding 1,2,3	mo + – VH (>1 yr) + – H (4 mo to 1 yr) + - M (1 mo to 4 mo) + - L (1 wk to 1 mo) + - VL (<1 wk) 0	Planning Scoping Pr Dsn/Env Pr[2] Enviro Permits ROW/Util/RR Final Design Procurement Construction Operations Replacement Funding 1,2,3	M man-hrs + – VH (>25%) + – H (10% to 25%) + - M (3% to 10%) + - L (1% to 3%) + - VL (<1%) 0	Planning Scoping Pr Dsn/Env Pr[2] Enviro Permits ROW/Util/RR Final Design Procurement Construction Operations Replacement Funding 1,2,3	$ M + – VH (>25%) + – H (10% to 25%) + - M (3% to 10%) + - L (1% to 3%) + - VL (<1%)	
		VH (0.7 to 1.0) H (0.4 to 0.7) M (0.2 to 0.4) L (0.05 to 0.2) VL (0.0 to 0.05)	$ M + – VH (>25%) + – H (10% to 25%) + - M (3% to 10%) + - L (1% to 3%) + - VL (<1%) 0	Planning Scoping Pr Dsn/Env Pr[2] Enviro Permits ROW/Util/RR Final Design Procurement Construction Operations Replacement Funding 1,2,3	mo + – VH (>1 yr) + – H (4 mo to 1 yr) + - M (1 mo to 4 mo) + - L (1 wk to 1 mo) + - VL (<1 wk) 0	Planning Scoping Pr Dsn/Env Pr[2] Enviro Permits ROW/Util/RR Final Design Procurement Construction Operations Replacement Funding 1,2,3	M man-hrs + – VH (>25%) + – H (10% to 25%) + - M (3% to 10%) + - L (1% to 3%) + - VL (<1%) 0	Planning Scoping Pr Dsn/Env Pr[2] Enviro Permits ROW/Util/RR Final Design Procurement Construction Operations Replacement Funding 1,2,3	$ M + – VH (>25%) + – H (10% to 25%) + - M (3% to 10%) + - L (1% to 3%) + - VL (<1%)	
		VH (0.7 to 1.0) H (0.4 to 0.7) M (0.2 to 0.4) L (0.05 to 0.2) VL (0.0 to 0.05)	$ M + – VH (>25%) + – H (10% to 25%) + - M (3% to 10%) + - L (1% to 3%) + - VL (<1%) 0	Planning Scoping Pr Dsn/Env Pr[2] Enviro Permits ROW/Util/RR Final Design Procurement Construction Operations Replacement Funding 1,2,3	mo + – VH (>1 yr) + – H (4 mo to 1 yr) + - M (1 mo to 4 mo) + - L (1 wk to 1 mo) + - VL (<1 wk) 0	Planning Scoping Pr Dsn/Env Pr[2] Enviro Permits ROW/Util/RR Final Design Procurement Construction Operations Replacement Funding 1,2,3	M man-hrs + – VH (>25%) + – H (10% to 25%) + - M (3% to 10%) + - L (1% to 3%) + - VL (<1%) 0	Planning Scoping Pr Dsn/Env Pr[2] Enviro Permits ROW/Util/RR Final Design Procurement Construction Operations Replacement Funding 1,2,3	$ M + – VH (>25%) + – H (10% to 25%) + - M (3% to 10%) + - L (1% to 3%) + - VL (<1%)	
		VH (0.7 to 1.0) H (0.4 to 0.7) M (0.2 to 0.4) L (0.05 to 0.2) VL (0.0 to 0.05)	$ M + – VH (>25%) + – H (10% to 25%) + - M (3% to 10%) + - L (1% to 3%) + - VL (<1%) 0	Planning Scoping Pr Dsn/Env Pr[2] Enviro Permits ROW/Util/RR Final Design Procurement Construction Operations Replacement Funding 1,2,3	mo + – VH (>1 yr) + – H (4 mo to 1 yr) + - M (1 mo to 4 mo) + - L (1 wk to 1 mo) + - VL (<1 wk) 0	Planning Scoping Pr Dsn/Env Pr[2] Enviro Permits ROW/Util/RR Final Design Procurement Construction Operations Replacement Funding 1,2,3	M man-hrs + – VH (>25%) + – H (10% to 25%) + - M (3% to 10%) + - L (1% to 3%) + - VL (<1%) 0	Planning Scoping Pr Dsn/Env Pr[2] Enviro Permits ROW/Util/RR Final Design Procurement Construction Operations Replacement Funding 1,2,3	$ M + – VH (>25%) + – H (10% to 25%) + - M (3% to 10%) + - L (1% to 3%) + - VL (<1%)	

Unmitigated Risk Factor Assessment

Item	Risk or Opportunity (from Risk Register by item#) (add rows as needed)	Assessed Probability of Occurrence (0 to 1, or rating*)	Assessed Impacts (if occur) (*ratings as defined by range categories –defaults shown)						Calculated[1]	
			Mean Direct Cost Change $ to Activity (uninflated $M, or rating*)	Activity $ Affected (circle)	Mean Duration Change T to Activity (months, or rating*)	Activity T Affected (circle)	Mean Disruption Change D to Activity (M man-hrs, or rating*)	Activity D Affected (circle)	Severity (equivalent inflated $M, or rating*)	Rank
EXAMPLE (showing mean values and ratings) Note: [1]*Considers extended OHs, inflation, and values of schedule and disruption* [2] Pr Dsn/Env Pr = preliminary design and environmental process										
RUi	Landowner(s) unwilling to sell parcel <xxx>	0.5 VH (0.7 to 1.0) H (0.4 to 0.7) M (0.2 to 0.4) L (0.05 to 0.2) VL (0.0 to 0.05)	+$0.5M + – VH (>25%) + – H (10% to 25%) + - M (3% to 10%) + - L (1% to 3%) + - VL (<1%) 0	Planning Scoping Pr Dsn/Env Pr[2] Enviro Permits ROW/Util/RR Final Design Procurement Construction Operations Replacement Funding 1,2,3	+2 mo + – VH (>1 yr) + – H (4 mo to 1 yr) + - M (1 mo to 4 mo) + - L (1 wk to 1 mo) + - VL (<1 wk) 0	Planning Scoping Pr Dsn/Env Pr[2] Enviro Permits ROW/Util/RR Final Design Procurement Construction Operations Replacement Funding 1,2,3	0 M man-hrs + – VH (>25%) + – H (10% to 25%) + - M (3% to 10%) + - L (1% to 3%) + - VL (<1%) 0	Planning Scoping Pr Dsn/Env Pr[2] Enviro Permits ROW/Util/RR Final Design Procurement Construction Operations Replacement Funding 1,2,3	+$0.3M + – VH (>25%) + – H (10% to 25%) + - M (3% to 10%) + - L (1% to 3%) + - VL (<1%)	1
		VH (0.7 to 1.0) H (0.4 to 0.7) M (0.2 to 0.4) L (0.05 to 0.2) VL (0.0 to 0.05)	$ M + – VH (>25%) + – H (10% to 25%) + - M (3% to 10%) + - L (1% to 3%) + - VL (<1%) 0	Planning Scoping Pr Dsn/Env Pr[2] Enviro Permits ROW/Util/RR Final Design Procurement Construction Operations Replacement Funding 1,2,3	mo + – VH (>1 yr) + – H (4 mo to 1 yr) + - M (1 mo to 4 mo) + - L (1 wk to 1 mo) + - VL (<1 wk) 0	Planning Scoping Pr Dsn/Env Pr[2] Enviro Permits ROW/Util/RR Final Design Procurement Construction Operations Replacement Funding 1,2,3	M man-hrs + – VH (>25%) + – H (10% to 25%) + - M (3% to 10%) + - L (1% to 3%) + - VL (<1%) 0	Planning Scoping Pr Dsn/Env Pr[2] Enviro Permits ROW/Util/RR Final Design Procurement Construction Operations Replacement Funding 1,2,3	$ M + – VH (>25%) + – H (10% to 25%) + - M (3% to 10%) + - L (1% to 3%) + - VL (<1%)	
		VH (0.7 to 1.0) H (0.4 to 0.7) M (0.2 to 0.4) L (0.05 to 0.2) VL (0.0 to 0.05)	$ M + – VH (>25%) + – H (10% to 25%) + - M (3% to 10%) + - L (1% to 3%) + - VL (<1%) 0	Planning Scoping Pr Dsn/Env Pr[2] Enviro Permits ROW/Util/RR Final Design Procurement Construction Operations Replacement Funding 1,2,3	mo + – VH (>1 yr) + – H (4 mo to 1 yr) + - M (1 mo to 4 mo) + - L (1 wk to 1 mo) + - VL (<1 wk) 0	Planning Scoping Pr Dsn/Env Pr[2] Enviro Permits ROW/Util/RR Final Design Procurement Construction Operations Replacement Funding 1,2,3	M man-hrs + – VH (>25%) + – H (10% to 25%) + - M (3% to 10%) + - L (1% to 3%) + - VL (<1%) 0	Planning Scoping Pr Dsn/Env Pr[2] Enviro Permits ROW/Util/RR Final Design Procurement Construction Operations Replacement Funding 1,2,3	$ M + – VH (>25%) + – H (10% to 25%) + - M (3% to 10%) + - L (1% to 3%) + - VL (<1%)	
		VH (0.7 to 1.0) H (0.4 to 0.7) M (0.2 to 0.4) L (0.05 to 0.2) VL (0.0 to 0.05)	$ M + – VH (>25%) + – H (10% to 25%) + - M (3% to 10%) + - L (1% to 3%) + - VL (<1%) 0	Planning Scoping Pr Dsn/Env Pr[2] Enviro Permits ROW/Util/RR Final Design Procurement Construction Operations Replacement Funding 1,2,3	mo + – VH (>1 yr) + – H (4 mo to 1 yr) + - M (1 mo to 4 mo) + - L (1 wk to 1 mo) + - VL (<1 wk) 0	Planning Scoping Pr Dsn/Env Pr[2] Enviro Permits ROW/Util/RR Final Design Procurement Construction Operations Replacement Funding 1,2,3	M man-hrs + – VH (>25%) + – H (10% to 25%) + - M (3% to 10%) + - L (1% to 3%) + - VL (<1%) 0	Planning Scoping Pr Dsn/Env Pr[2] Enviro Permits ROW/Util/RR Final Design Procurement Construction Operations Replacement Funding 1,2,3	$ M + – VH (>25%) + – H (10% to 25%) + - M (3% to 10%) + - L (1% to 3%) + - VL (<1%)	
		VH (0.7 to 1.0) H (0.4 to 0.7) M (0.2 to 0.4) L (0.05 to 0.2) VL (0.0 to 0.05)	$ M + – VH (>25%) + – H (10% to 25%) + - M (3% to 10%) + - L (1% to 3%) + - VL (<1%) 0	Planning Scoping Pr Dsn/Env Pr[2] Enviro Permits ROW/Util/RR Final Design Procurement Construction Operations Replacement Funding 1,2,3	mo + – VH (>1 yr) + – H (4 mo to 1 yr) + - M (1 mo to 4 mo) + - L (1 wk to 1 mo) + - VL (<1 wk) 0	Planning Scoping Pr Dsn/Env Pr[2] Enviro Permits ROW/Util/RR Final Design Procurement Construction Operations Replacement Funding 1,2,3	M man-hrs + – VH (>25%) + – H (10% to 25%) + - M (3% to 10%) + - L (1% to 3%) + - VL (<1%) 0	Planning Scoping Pr Dsn/Env Pr[2] Enviro Permits ROW/Util/RR Final Design Procurement Construction Operations Replacement Funding 1,2,3	$ M + – VH (>25%) + – H (10% to 25%) + - M (3% to 10%) + - L (1% to 3%) + - VL (<1%)	

Table C-1. Risk-Factor Rating Scale Definitions (from template – see Attachment 1)

Base Cost through Construction	16.04	(CY $M)
Base Schedule	35	Months
Base Disruption through Construction	0.70	M-Hr

Data Entry Type	Percent

COST CHANGE

Adjectival Rating	Percent of Base Cost		Absolute Value (CY $M)		Expected Mean Value	
	Low	High	Low	High	Percent	Absolute
VH	24.94	49.88	4.00	8.00	37.41	6.00
H	9.98	24.94	1.60	4.00	17.46	2.80
M	3.12	9.98	0.50	1.60	6.55	1.05
L	1.25	3.12	0.20	0.50	2.18	0.35
VL	0.00	1.25	0.00	0.20	0.62	0.10

DURATION CHANGE

Adjectival Rating	Percent of Base Schedule		Absolute Value (months)		Expected Mean Value	
	Low	High	Low	High	Percent	Absolute
VH	34.29	68.57	12.00	24.00	51.43	18.00
H	11.43	34.29	4.00	12.00	22.86	8.00
M	2.86	11.43	1.00	4.00	7.14	2.50
L	0.71	2.86	0.25	1.00	1.79	0.63
VL	0.00	0.71	0.00	0.25	0.36	0.13

DISRUPTION CHANGE

Adjectival Rating	Percent of Base Disruption		Absolute Value (M person-Hrs)		Expected Mean Value	
	Low	High	Low	High	Percent	Absolute
VH	28.57	57.14	0.20	0.40	42.86	0.30
H	14.29	28.57	0.10	0.20	21.43	0.15
M	0.00	14.29	0.00	0.10	7.14	0.05
L	0.00	0.00	0.00	0.00	0.00	0.00
VL	0.00	0.00	0.00	0.00	0.00	0.00

PROBABILITY OF OCCURRENCE

Adjectival Rating		Probability Range	Mean Probability
	Low	High	
VH	0.70	1.00	0.85
H	0.40	0.70	0.55
M	0.20	0.40	0.30
L	0.05	0.20	0.13
VL	0.00	0.05	0.03

ATTACHMENT C. UNMITIGATED RISK REGISTER
(Solution: with risk assessments)

The Risk Register for the project (as described in Attachments A and B) was developed (by consensus) by a facilitated group of project team and project-independent subject matter experts, as follows:

- Risks were first brainstormed and then categorized, edited, and added to create a comprehensive and non-overlapping set (see Table C-2 for the resulting set, and see the template in Attachment I for initial steps). As previously noted, only performance (and thus risks) through construction has been focused on for now.
- The factors that define risks (i.e., impacts and probability of occurrence) before any additional mitigation ("unmitigated") were then assessed for each of the risks in terms of mean value/ratings (see Table C-1 for rating "scale" definitions for assessments, and Table C-2 for the assessments for each risk, and see the template in Attachment I for a summary of those assessments)

Table C-1. Risk-Factor Rating Scale Definitions (from template – see Attachment 1)

Base Cost through Construction	16.04	(CY $M)
Base Schedule	35	Months
Base Disruption through Construction	0.70	M-Hr

Data Entry Type	Percent

COST CHANGE

Adjectival Rating	Percent of Base Cost		Absolute Value (CY $M)		Expected Mean Value	
	Low	High	Low	High	Percent	Absolute
VH	24.94	49.88	4.00	8.00	37.41	6.00
H	9.98	24.94	1.60	4.00	17.46	2.80
M	3.12	9.98	0.50	1.60	6.55	1.05
L	1.25	3.12	0.20	0.50	2.18	0.35
VL	0.00	1.25	0.00	0.20	0.62	0.10

DURATION CHANGE

Adjectival Rating	Percent of Base Schedule		Absolute Value (months)		Expected Mean Value	
	Low	High	Low	High	Percent	Absolute
VH	34.29	68.57	12.00	24.00	51.43	18.00
H	11.43	34.29	4.00	12.00	22.86	8.00
M	2.86	11.43	1.00	4.00	7.14	2.50
L	0.71	2.86	0.25	1.00	1.79	0.63
VL	0.00	0.71	0.00	0.25	0.36	0.13

DISRUPTION CHANGE

Adjectival Rating	Percent of Base Disruption		Absolute Value (M person-Hrs)		Expected Mean Value	
	Low	High	Low	High	Percent	Absolute
VH	28.57	57.14	0.20	0.40	42.86	0.30
H	14.29	28.57	0.10	0.20	21.43	0.15
M	0.00	14.29	0.00	0.10	7.14	0.05
L	0.00	0.00	0.00	0.00	0.00	0.00
VL	0.00	0.00	0.00	0.00	0.00	0.00

PROBABILITY OF OCCURRENCE

Adjectival Rating	Probability Range		Mean Probability
	Low	High	
VH	0.70	1.00	0.85
H	0.40	0.70	0.55
M	0.20	0.40	0.30
L	0.05	0.20	0.13
VL	0.00	0.05	0.03

Table C-2. Unmitigated Risk Register for Mean-Value / Rating Assessment (see Table C-1 for rating scale definitions; for risks through construction only)

Item	Risk or Opportunity	IF Conducting only a Qualitative Risk Assessment (enter either Mean Ratings per scale or Mean Values)			
		Probability of Occurrence (%)	Cost Change to Activity (current $million)	Schedule Change to Activity (months)	Disruption Change to Activity (million person-hrs lost)
	Planning				
PL1 Excluded	**Project funding delayed or reduced** The project is currently funded for an amount that QDOT feels is adequate. However, if additional funding is required (i.e., if costs increase for various reasons), might be a delay in obtaining the additional funding. However, QDOT's objective is to evaluate the project's risk assuming funding is available without delay. Hence, QDOT wants to *exclude* uncertainty in funding at this time (but might later treat that uncertainty by defining separate "model scenarios" to evaluate the impact of various potential funding delays). Otherwise, *exclude* the risk that funding is cancelled or substantially reduced (so that scope reduction is required, which would lead to a "different" project).				
PL2	**Opposition to removing access to US 555 from 12th Street** Several businesses rely on this access and might protest or challenge the removal of the access. However, removal of that access is necessary for the project. Hence, this design decision is unlikely to be reversed. However, some mitigation might be required as compensation.	L	+VL to D/B Construction	0	0
PL3 Elsewhere	**Opposition to "splitting" alignment of SH 111 in the interchange area** The City does not like this alternative. This issue is captured as a factor influencing the probability that this split will occur – see risk D2.				
PL4 Minor	**Other stakeholder issues not captured separately**				

Item	Risk or Opportunity	IF Conducting only a Qualitative Risk Assessment (enter either Mean Ratings per scale or Mean Values)			
		Probability of Occurrence (%)	Cost Change to Activity (current $million)	Schedule Change to Activity (months)	Disruption Change to Activity (million person-hrs lost)
	Scoping				
SC1 Minor	**Change in East-West project limits** Project might be required (either for political or operational reasons) to improve longer or shorter stretch of US 555 than assumed in the base estimate. The project team and QDOT believe this is unlikely because funding is not available for such a significant change, and the need is not clear (for the project to perform as desired).				
S2C Minor	**Change in North-South project limits** Project might be required (either for political or operational reasons) to improve longer or shorter stretch of SH 111 than assumed in the base estimate. Similar to discussion for S1.				
SC3	**Additional local improvements required** For example: • More improvements on Main Street away from US 555 • More improvements on North and/or South Avenues away from SH 111 • More improvements on West and/or East Streets away from US 555 Schedule impacts are design-related.	M	+L to D/B Construction	+L to Prelim Design	0
SC4 Minor	**Increased aesthetics for US 555 / SH 111 interchange** For example, "gateway" appearance, decorative lighting, etc. The project already includes reasonable aesthetics, and a significant 'gateway' theme is well outside the project's budget. The City would therefore have to pay for such improvements, which it is unlikely to be able to afford.				

Item	Risk or Opportunity	IF Conducting only a Qualitative Risk Assessment (enter either Mean Ratings per scale or Mean Values)			
		Probability of Occurrence (%)	Cost Change to Activity (current $million)	Schedule Change to Activity (months)	Disruption Change to Activity (million person-hrs lost)
SC5	**Replace culvert over Wandering Creek** Base assumes that the state fisheries agency will allow widening this culvert, especially since no listed fish species are believed to live this far up Wandering Creek. The fisheries agency has, however, required replacement of similar culverts on nearby projects.	M	+L to D/B Construction	0	0
SC6	**Provide new lighting throughout project** Base assumes new lighting only in the interchange area. The team increasingly believes that new lighting will be required throughout (mainly because they will have to relocate existing lighting to widen the roadway anyway).	H	+M To D/B Construction	0	0
SC7 Minor	**ITS added to this project** Unlikely – not funded and the system-wide ITS development is lagging this project.				
	Preliminary Design and Environmental Process <u>For all relevant risks in this category, the following conditions apply</u>: Each risk includes all related / correlated design, environmental, right-of-way, and construction impacts. Impacts shown are in addition to any assessed base uncertainties.				
PD1	**Shift alignment of US 555 at east end of project** This would reduce wetland impacts by shifting alignment to the south. However, there is some resistance (City) to shifting the alignment this way because of the number of business displacements it would cause. It could also cause a problem with geometry at the intersection of East Street. The group therefore thinks that this is unlikely to occur. If it did, however, the impacts would include reduced wetland impacts, increased right-of-way costs (mostly due to additional demolition and business relocations), additional design time. The change in construction cost would be minimal.	VL	+M to ROW, Utilities, Railroads	+M to ROW, Utilities, Railroads	0

Item	Risk or Opportunity	IF Conducting only a Qualitative Risk Assessment (enter either Mean Ratings per scale or Mean Values)			
		Probability of Occurrence (%)	Cost Change to Activity (current $million)	Schedule Change to Activity (months)	Disruption Change to Activity (million person-hrs lost)
PD2 Minor	**Split alignment of SH 111 at US 555 interchange** Instead of widening on existing alignment; would allow for more rapid construction but requires additional ROW. Benefits (reduced construction duration) probably don't outweigh the detriments (additional ROW; less efficient traffic flow; re-design). The City and at least two public groups do not like this alternative. Therefore, it is unlikely to occur.				
PD3	**Change in configuration of SH 111 / US 555 interchange** QDOT's preliminary design (SPUI) is one of several viable alternatives, and it is expected that the contractor could propose a suitable alternative. It is uncertain how much such a change might cost relative to the currently-assumed alternative (could be more, could be less), but QDOT won't accept a design that is significantly more expensive. Includes potential change in structure and foundation type/size, but assumes that an appropriate accelerated bridge construction technique will be used.	0	0 (could be a significant increase or decrease with equal likelihood; hence, on average, no change)	0	0
PD4	**Ground improvement required in interchange area** QDOT HQ design is also concerned that a recent change to the seismic design criteria (which is still being evaluated) might require localized ground improvement to mitigate for liquefaction potential. The project team thinks this is unlikely, but could have significant impacts if it occurs.	L	+M to D/B Construction	+L to D/B Construction	0
PD5	**Shoulders required on US 555** For example, if FHWA or QDOT HQ Design both don't approve the no-shoulder exception/deviation. The project team is reasonably confident that this design exception will be approved based on recent, similar approvals for other nearby projects.	VL	+H to D/B Construction	+M to D/B Construction	0

Item	Risk or Opportunity	IF Conducting only a Qualitative Risk Assessment (enter either Mean Ratings per scale or Mean Values)			
		Probability of Occurrence (%)	Cost Change to Activity (current $million)	Schedule Change to Activity (months)	Disruption Change to Activity (million person-hrs lost)
	However, if shoulders are required, the impacts are significant: additional right-of-way would be required, construction costs would increase, the draft EA might have to be modified (wetland impacts would increase), and design time (prior to RFP) would increase.				
PD6	**Shoulders required on SH 111** For example, if QDOT HQ Design doesn't approve the no-shoulder exception/deviation. Similar to the discussion and assessments for risk D5. For the quantitative risk analysis: Risk D6 is correlated to risk D5. If risk D5 does not occur (shoulders not required on US 555), then it is likely that shoulders won't be required on this facility either. If risk D5 does occur, then shoulders will likely be required for SH 111 as well.	VL	+H to D/B Construction	+M to D/B Construction	0
PD7 Minor	**Additional cost for signalized intersections** Excludes any change in the number of intersections that is captured separately in risks related to project limits (i.e., risks S1 and S2).				
PD8	**Change in pavement section and/or type** The base assumes concrete pavement to provide longevity (one of the project's goals). QDOT is therefore most likely to specify a concrete pavement. Asphalt pavement might be selected to provide compatibility with existing pavement (beyond the project limits) and to save initial cost. However, QDOT considers maximizing longevity (including life-cycle costs) a higher priority than saving initial capital cost.	M	-M to D/B Construction	0	0

Item	Risk or Opportunity	IF Conducting only a Qualitative Risk Assessment (enter either Mean Ratings per scale or Mean Values)			
		Probability of Occurrence (%)	Cost Change to Activity (current $million)	Schedule Change to Activity (months)	Disruption Change to Activity (million person-hrs lost)
PD9 Minor	**Rehabilitate instead of reconstruct existing roadway (e.g., overlay instead)** See *Guide* Appendix C, Appendix D, or Table D-4f. Existing roadway is 20 years old; might not be cost effective to rehabilitate when have to build new lanes anyway. In addition, rehab is not as likely to meet the project objective of maximizing longevity of the facility. Note: for the quantitative risk analysis, this risk is correlated to risk D8 (impacts are a function of the outcome of that risk).				
PD10 Minor	**Change in stormwater design standards** The design incorporates the latest standards, which are only two years old. Hence, it is unlikely that new standards will emerge in this project's timeframe.				
PD11	**Cannot use City sewer system for project runoff (or City charges for use)** The City might deny use or charge QDOT for various upgrades to the system to accommodate stormwater runoff from this project. The project team and QDOT management are "almost certain" that the City will ultimately allow use of the City's system (the City needs this project, and the additional load on the sewer system is not substantial), but will most likely ask for money to help upgrade its system. QDOT would probably capitulate as this is the best option from a cost and time perspective. This cost would occur during the project's "utility relocations" phase. This issue is correlated with the likely request by the City to help pay for a water and sewer-line relocation (see risk U2 under utilities risks). For the quantitative risk analysis, the group assesses that if risk U2 occurs (i.e., QDOT decides to help pay for relocation), then this risk is much less likely to occur.	M	+M to ROW, Utilities, Railroads	+L to ROW, Utilities, Railroads	0

Item	Risk or Opportunity	IF Conducting only a Qualitative Risk Assessment (enter either Mean Ratings per scale or Mean Values)			
		Probability of Occurrence (%)	Cost Change to Activity (current $million)	Schedule Change to Activity (months)	Disruption Change to Activity (million person-hrs lost)
PD12	**Structures impacted by Main Street realignment are eligible for Historic Register** Can reasonably capture the range of credible possibilities with the following set of potential (mutually-exclusive) scenarios / outcomes: A. Not historic structures (base assumption) B. Historic structures, but no significant impact to project cost or schedule (e.g., document, then acquire) C. Historic structures, creating significant impact to project cost or schedule (e.g., have to relocate structures; structures are contaminated; or have to shift project alignment to avoid)	L	+M to ROW, Utilities, Railroads	+M to ROW, Utilities, Railroads	0
PD13	**Change in environmental documentation** Only treat this issue here if not captured separately by specific triggers / issues elsewhere (e.g., design changes). Base assumes an EA, but an EIS might be required if impacts are greater than assumed. Can reasonably capture the range of credible possibilities with the following set of potential (mutually-exclusive) scenarios / outcomes: A. Complete EA as planned (base assumption) B. Complete EA with additional effort, but with no significant changes to the project C. EIS required, but with no significant changes to the project **D.** EIS required, resulting in significant change to the project design, right-of-way, and/or construction	L	+M to Prelim Design / Environ-mental Process	+H to Prelim Design / Environ-mental Process	0
PD14	**Delays completing environmental documentation** From various causes if not already captured separately (i.e., significant design changes; change in type of environmental documentation, risk E2). For example: • Additional impacts identified • Process delays (internal or external reviews, comments, and/or approvals)	M	No direct cost (schedule-related only)	+M to Prelim Design / Environ-mental Process	0

Item	Risk or Opportunity	IF Conducting only a Qualitative Risk Assessment (enter either Mean Ratings per scale or Mean Values)			
		Probability of Occurrence (%)	Cost Change to Activity (current $million)	Schedule Change to Activity (months)	Disruption Change to Activity (million person-hrs lost)
PD15	**Encounter unanticipated contamination in interchange area** If encountered, likely to be hydrocarbon-based soil and/or groundwater contamination.	M	+VL to D/B Construction	0	0
PD16	**Additional wetland mitigation required for planned alignment** Additional mitigation could be required for various reasons. For example: • Change in mitigation requirements (ratios, buffers) • Change in wetland classification • Impacts different than assumed (i.e., underestimated originally) (this could happen for the current or shifted alignment) Note: for the quantitative risk analysis, this risk is partially a function of any potential shift in alignment at the east end of the project (risk D1). If risk D1 occurs and the 'base' wetland impacts are reduced, the probability of this risk is reduced.	M	+L to D/B Construction	0	0
	Environmental Permits				
EP1 Minor	**Challenge to environmental determination or permits** For any reason not captured elsewhere. Could come from organized public groups for various reasons. However, very unlikely for the base project (chances could increase for some alternatives like shifting the alignment at the east end of the project, but these impacts are captured in those risks).				
EP2	**Delay obtaining the 404 permit** Either from internal or USACE process delays (review, approval) or deficiencies in QDOT's application. Note that this risk is assumed to be approximately independent of risks D1 and E6 (delay issues could occur regardless of the outcomes from those risks).	L	No direct costs (schedule-related only)	+M to Environmental Permits	0

Item	Risk or Opportunity	IF Conducting only a Qualitative Risk Assessment (enter either Mean Ratings per scale or Mean Values)			
		Probability of Occurrence (%)	Cost Change to Activity (current $million)	Schedule Change to Activity (months)	Disruption Change to Activity (million person-hrs lost)
	Right-of-Way				
RU1	**Uncertainty in ROW inflation rate** Regionally; before considering the localized effects of accelerating development, which is captured separately. Despite a sag in the economy, property prices have held steady, and appear to even be increasing slightly. However, this could change (e.g., if this area is lagging the economy). Over the short term of this project, local indicators and the ROW professionals anticipate an average increase of approximately 3%/year in the area.	H	+M to ROW, Utilities, Railroads	0	0
RU2	**Accelerating pace of development in interchange area** Beyond the regional ROW inflation rate captured in R1. Several new developments are planned in the area, and at least one could be implemented before this project is let. The impact to this project would be increased acquisition and perhaps relocation costs compared to what is currently assumed in the estimate.	M	+M to ROW, Utilities, Railroads	+M to ROW, Utilities, Railroads	0
RU3	**Unwilling sellers** Note: base cost excludes condemnation costs/allowance. This risk is separate from risk R2. Particularly in the US 555 / SH 111 interchange area, property owners might not want to relocate, leading to increased cost to acquire ROW (e.g., have to go through condemnation). Note that condemnation does not normally extend the right-of-way acquisition timeframe, because QDOT can usually quickly gain possession-and-use of condemned properties.	H	+M to ROW, Utilities, Railroads	0	0

Item	Risk or Opportunity	IF Conducting only a Qualitative Risk Assessment (enter either Mean Ratings per scale or Mean Values)			
		Probability of Occurrence (%)	Cost Change to Activity (current $million)	Schedule Change to Activity (months)	Disruption Change to Activity (million person-hrs lost)
RU4 In R2	**Additional relocation or demolition required** Excludes additional relocation or demolition that might be required to accommodate changes in design or scope, which are captured as part of those separate risks. Excludes contamination, which is captured separately. For example, multi-tenant properties could be complex to relocate. The group assesses that this potential additional cost and time was captured in risk R2.				
RU5 Minor	**Additional ROW required for planned project** Excludes additional ROW that might be required for changes in design or scope, which are captured as part of those separate risks. For example, initial estimates for required ROW for the assumed design were incorrect or incomplete. The group assesses that the potential significant changes were captured as part of other risks.				
RU6	**Other delays to ROW planning** For reasons not captured as part of other specific risks. For example, late changes in design result in changes in ROW plans, or internal QDOT delays to ROW plan development.	M	No direct costs (schedule-related only)	+L to ROW, Utilities, Railroads	0
	Utilities				
RU7	**Telecom utility wants a cost-sharing agreement** The Telecom's presence in the project right-of-way pre-dates QDOT's, so QDOT cannot force relocation. The Telecom just recently replaced its fiber optic backbone, so not likely to replace without some sort of cost sharing (or, at least, replace within the timeframe needed by this project).	M	+L To ROW, Utilities, Railroads	0	0

Item	Risk or Opportunity	IF Conducting only a Qualitative Risk Assessment (enter either Mean Ratings per scale or Mean Values)			
		Probability of Occurrence (%)	**Cost Change to Activity (current $million)**	**Schedule Change to Activity (months)**	**Disruption Change to Activity (million person-hrs lost)**
RU8	**QDOT helps City pay for water and sewer-line relocation** See *Guide* Appendix C (rapid renewal strategies / methods). To help maintain project schedule, QDOT might help pay for the sewer-line relocation. This "risk" is therefore really a project / policy decision within QDOT's control. This decision comes at a monetary cost but avoids schedule delay (as reflected to the right). Note that for the quantitative risk analysis, the outcome of this risk affects the likelihood of occurrence for risk PD11.	H	+M To ROW, Utilities, Railroads	0	0
RU9 Minor	**Other utility relocations not completed on time** For issues not captured separately in other risks. For various reasons, including delayed negotiations, design, or relocation work itself.				
RU10 Minor	**Damage existing utility or encounter unanticipated utility during construction** Possible, but the time impacts are quickly mitigated. The cost impact would be the D/B contractor's responsibility.				
	Contracting and Procurement				
CP1	**Uncertainty in construction-cost inflation rate** Excludes contracting market conditions and material-supply issues, which are captured separately in risks CP2 and CP3. This issue includes uncertainty in the general regional and national trends in construction-industry cost changes over time (general inflation), with reasonable adjustment for this region.	H	+M to D/B Construction	0	0
CP2	**Uncertain Design/Build contracting market conditions at time of bid** See *Guide*, Appendix D-2 or Table D-6.	25% (note: team felt ratings	+10% of base construction	+1 to Procurement	0

Item	Risk or Opportunity	IF Conducting only a Qualitative Risk Assessment (enter either Mean Ratings per scale or Mean Values)			
		Probability of Occurrence (%)	Cost Change to Activity (current $million)	Schedule Change to Activity (months)	Disruption Change to Activity (million person-hrs lost)
	Separate from general construction inflation and material-supply issues, which are captured in risks CP1 and CP3, respectively. This issue includes uncertainty in pricing strategy and other contractor competition factors. QDOT expects four proposals/bids, which could improve competition. However, recent experience for similar projects is that bids are coming in above QDOT's Engineer's Estimates. Can reasonably capture the range of credible possibilities with the following set of potential (mutually-exclusive) scenarios / outcomes: A. Market conditions are favorable (competitive), and bids come in below the base estimate B. Market conditions are similar to assumed in the estimate (minimal change from base) C. Market conditions are not competitive, so bids are higher than the base but still acceptable (below threshold for canceling the procurement) D. Market is not competitive, and no acceptable bids are received – requires re-bidding and perhaps repackaging to get acceptable bids.	were insufficient to describe this risk)	cost to D/B Construction		
CP3 Elsewhere	**Material-supply issues** Various local factors could affect the availability of materials for this project. For example: • Cannot locate an appropriate fill source • Fill source is farther away than assumed • Aggregate prices higher than anticipated • Steel prices higher than anticipated • Cement prices higher than anticipated The group believes that all of these issues are captured in either risk CP1 or CP2.				

Item	Risk or Opportunity	IF Conducting only a Qualitative Risk Assessment (enter either Mean Ratings per scale or Mean Values)			
		Probability of Occurrence (%)	Cost Change to Activity (current $million)	Schedule Change to Activity (months)	Disruption Change to Activity (million person-hrs lost)
CP4 Minor	**Change in project delivery method** See *Guide* Appendix D-2 or Table 4-6. Contract other than through the assumed single Design/Build contract. Only treat here if not already captured under the market conditions risk (CP2). It is unlikely that QDOT will change to a traditional delivery method (e.g., Design/Bid/Build) given the rapid renewal-type objectives for this project. Other delivery alternatives are unlikely, either because enabling legislation does not exist or QDOT does not have adequate experience with those delivery methods.				
CP5 Minor	**Accelerate pre-construction activities to reach NTP sooner** See *Guide* Appendix C, Appendix D-2 or Table D-3. If not captured separately under Design, Environmental, and/or ROW risk categories. To reach NTP more quickly, QDOT could adopt a more-aggressive pre-construction strategy. For example: • Moving to NTP before permitting is complete. • Could seek streamlined environmental process or design-approval process (see *Guide*, Appendix D-2 or Table D-3). However, it might be too late to implement these for this project (would have been better to plan for this in advance of starting work on the project). The group believes that a more-aggressive permitting vs. NTP strategy is possible, but introduces its own risks (i.e., if NTP is issued before the environmental permits are complete, the contractor could have grounds for				

Item	Risk or Opportunity	IF Conducting only a Qualitative Risk Assessment (enter either Mean Ratings per scale or Mean Values)			
		Probability of Occurrence (%)	Cost Change to Activity (current $million)	Schedule Change to Activity (months)	Disruption Change to Activity (million person-hrs lost)
	significant claims if permit conditions change relative to the RFP). Hence, it is unlikely for QDOT to pursue this strategy.				
CP6 Minor	**Use incentives to accelerate D/B construction** See *Guide*, Appendix D-2 or Tables D-2 and D-6. The team believes that QDOT is unlikely to apply additional incentives – use of D/B delivery method and performance-based specs should provide adequate flexibility and incentive for the contractor to complete the project within QDOT's desired timeframe.				
CP7	**Issues with D/B design or submittals** For example: • Internal QDOT or FHWA delays reviewing and approving submissions • Errors or omissions in D/B submissions	M	No direct cost (schedule-related only)	+M to D/B Design	0
CP8	**Other problems with D/B contract procurement** See *Guide*, Appendix D-2 or Tables D-2 and D-6. Aside from issues captured separately (e.g., as part of market conditions risk). Note: project-cancelling issues are excluded; most of the remaining identified issues were assessed to be low likelihood and relatively low impact for this project. Hence, the group combined them into one 'larger' issue and assessed their combined potential impacts. Even so, the group believes that a significant problem is unlikely (especially given QDOT's reasonable history for such procurements). If something did occur, the most-likely impact to schedule would be during D/B procurement.	L	No direct cost (schedule-related only)	+L to Procurement	0

Item	Risk or Opportunity	IF Conducting only a Qualitative Risk Assessment (enter either Mean Ratings per scale or Mean Values)			
		Probability of Occurrence (%)	**Cost Change to Activity (current $million)**	**Schedule Change to Activity (months)**	**Disruption Change to Activity (million person-hrs lost)**
	For example: • Bid protest (pre-award or post-award) • Unclear contract documents • Contractor default • Bonding or insurance issues • QDOT unfamiliarity with D/B contracting • Approach to specifications (e.g., performance-based specs)				
	Construction				
CN1	**D/B construction phasing significantly different than assumed** Excludes specific changes to schedule and phasing related to changes in design, etc. that are captured under other risks. The base schedule is not believed to be overly optimistic or aggressive. It's impossible to know at this point how the D/B will actually construct the project, so the actual schedule and phasing could be significantly different than currently assumed.	25% (note: team felt ratings were insufficient to describe this risk)	No direct cost (schedule-related only)	-2 to D/B Construction	-0.1 to D/B Construction
CN2	**Additional Maintenance of Traffic required** See *Guide*, Appendix D-2 or Table D-4g. Either because the original plan doesn't work and needs to be modified, or the plan works but simply needs to be augmented.	H	+L to D/B Construction	+VL to D/B Construction	+M to D/B Construction
CN3	**Problems with planned accelerated bridge construction (ABC) technique** QDOT assumes the contractor will employ ABC (regardless of the structure type selected for the interchange; hence, this issue is approximately independent of risk D3). The performance of this planned rapid renewal method (accelerated bridge construction) is difficult to predict because the method the contractor will use is not known, and many ABC techniques are still evolving.	H	+L to D/B Construction	+L to D/B Construction	+L to D/B Construction

Item	Risk or Opportunity	IF Conducting only a Qualitative Risk Assessment (enter either Mean Ratings per scale or Mean Values)			
		Probability of Occurrence (%)	Cost Change to Activity (current $million)	Schedule Change to Activity (months)	Disruption Change to Activity (million person-hrs lost)
	Potential problems include (see *Guide*, Appendix D-2 or Table D-4b): • Selected technology doesn't work as planned (technical issue) • Delays procuring technology *Note that this risk does not apply if the SH 111 alignment is split at the interchange (construction is out of traffic; ABC is not employed).*				
CN4	**Unable to construct interchange embankments as rapidly as assumed** Base assumes rapid construction techniques for the approach embankments of the SH 111 overcrossing at the interchange with US 555. The performance of this planned rapid renewal method (rapid embankment construction) is difficult to predict for the following reasons (see *Guide*, Appendix D-2 or Table D-4c): • Uncertainty in subsurface conditions (soft soils are suspected); • Uncertainty in what method the contractor will choose; and • Uncertainty in performance of the selected method for actual subsurface conditions (e.g., method doesn't perform as intended). It is therefore unclear at this point how much benefit will be achieved relative to traditional embankment construction. If the method doesn't work, remedial measures will be needed to accelerate embankment construction, but with some loss of time.	M	+L to D/B Construction	+M to D/B Construction	+L to D/B Construction
CN5	**Difficult foundation installation** Separate from ground-improvement issues. Information is limited in the interchange area (additional geotechnical investigation is scheduled for later). However, anecdotal information indicates that near-surface ground conditions are poor enough to require deep foundations (assumed in the base).	L	+L to D/B Construction	+L to D/B Construction	+VL to D/B Construction

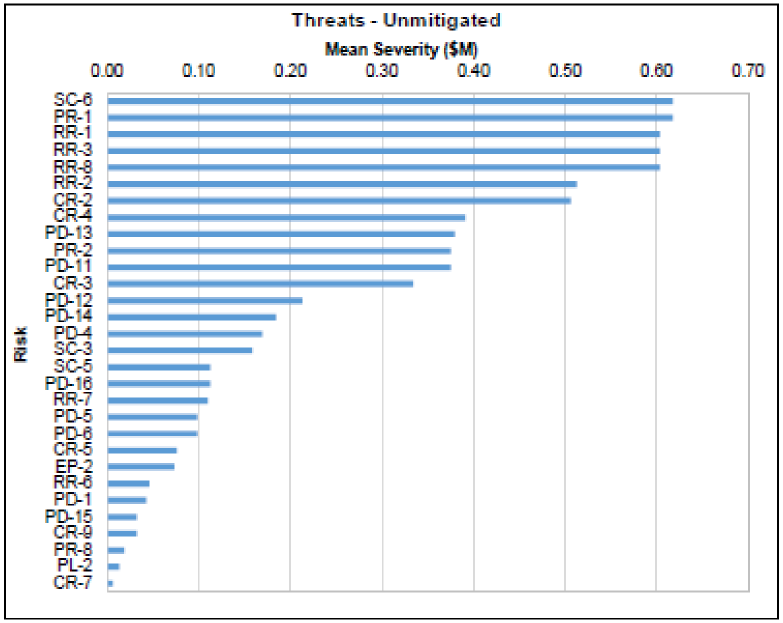
Item	Risk or Opportunity	IF Conducting only a Qualitative Risk Assessment (enter either Mean Ratings per scale or Mean Values)			
		Probability of Occurrence (%)	**Cost Change to Activity (current $million)**	**Schedule Change to Activity (months)**	**Disruption Change to Activity (million person-hrs lost)**
	Could encounter obstructions, have difficulty obtaining design capacity for various reasons, etc.				
CN6 Minor	**Severe weather event significantly impacts construction** This refers to specific, individual events, like earthquake or flood, during construction. Could result in either delay or significant damage. Very low likelihood of significant impact in this geographic location.				
CN7	**Colder-than-usual winter** Usually, construction work can proceed year-round in some manner (the base schedule accounts for this). However, an extreme winter could result in perhaps a one-month delay.	L	No direct cost (schedule-related only)	+VL to D/B Construction	+VL to D/B Construction
CN8 Minor	**Significant accident during construction** Low likelihood. If occurs, time impact is likely to be minimal and cost impacts could be covered by D/B insurance.				
CN9	**Limited construction staging area in vicinity of interchange** Either QDOT or the contractor will likely have to find a suitable staging area, but it might not be close to the interchange, which could increase contractor costs.	M	+VL to D/B Construction	0	0
CN10 Minor	**Fish window in Wandering Creek** Currently, no listed species are believed to inhabit Wandering Creek near US 555. Hence, in-water work windows are assumed to not apply. Even if a window did apply, however, the contractor should easily be able to stage culvert work to accommodate a window.				
CN11 Minor	**Non-compliance with permits during construction** Low likelihood of any significant non-compliance. Even if it does occur, low likelihood of significant cost impact (contractor's) or schedule impact (QDOT's schedule, but contractor financially responsible).				

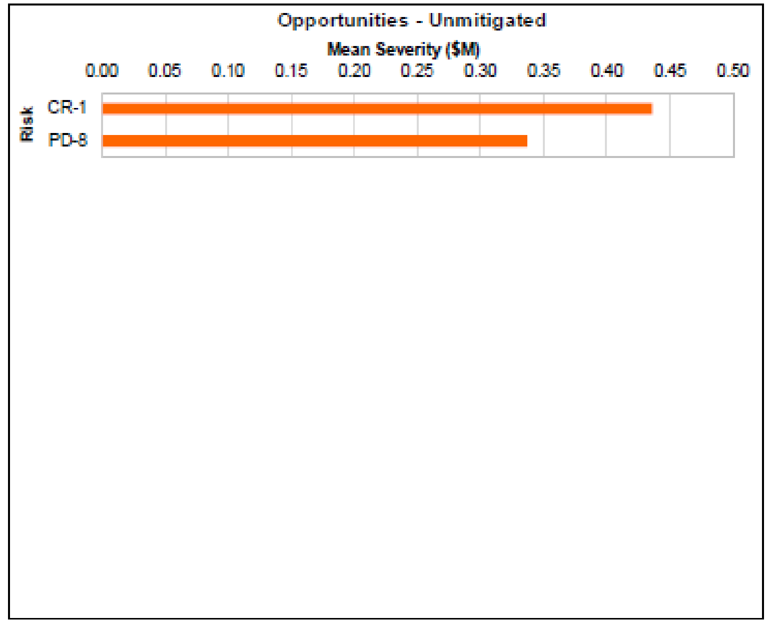
Item	Risk or Opportunity	IF Conducting only a Qualitative Risk Assessment (enter either Mean Ratings per scale or Mean Values)			
		Probability of Occurrence (%)	Cost Change to Activity (current $million)	Schedule Change to Activity (months)	Disruption Change to Activity (million person-hrs lost)
CN12	**Extended overheads as a function of project delays** Pre-construction (QDOT staff): $100k / month of delay Construction: • QDOT staff: $100k / month of delay • Contractor: For compensable delays, $250k / month of delay (modeled as $125k / month of total delay, assuming 50% of delays are compensable)	Not treated as a separate, explicit risk (results from other risks)			
	Minor and Unidentified Risks and Opportunities Aggregate effect of items labeled “Minor” above. “Major” means the items quantified above (i.e., all items other than those labeled “Minor” above)				
	Aggregate Minor Risks	H	+L	+L	+L
	Aggregate Minor Opportunities	H	-L	-L	-L
	Unidentified Risks	H	+L	+L	+L
	Unidentified Opportunities	H	-L	-L	-L

Notes:

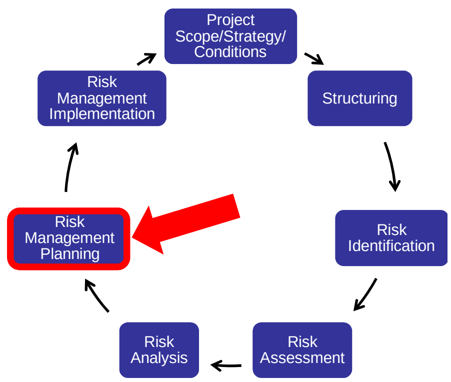
1. All cost impacts are assessed in current terms. Cost escalation is handled automatically through the simulation model, appropriately considering uncertainty in inflation rates and the affected project activities.
2. Except for “soft cost” uncertainties that are addressed separately, and unless noted otherwise, all cost impacts in this table are “fully loaded” with appropriate markups. Potential markups include items that may be treated as a percentage of the construction subtotal in the cost estimate, such as sales tax, mobilization, construction engineering, design, and allowances for miscellaneous items.

Unmitigated Risk Ranking Plots (Step 7 of R09 Template)





Module 7: Risk Management Planning



7-1

Risk Management Planning

- **Learning Outcomes**
- Objectives
- Risk Management Plan Steps
- QDOT Case Study
- Summary

7-2

Learning Outcomes

- Identify objectives Risk Management Planning
- Identify steps for Risk Management Planning
- Identify opportunities for risk allocation
- Describe and manage contingency and residual risk

7-3

Risk Management Planning

- Learning Outcomes
- **Objectives**
- Risk Management Plan Steps
- QDOT Case Study
- Summary

7-4

Risk Management Planning
(Objectives)

- Identify, evaluate, and plan potential actions to cost-effectively and proactively reduce key risks and exploit opportunities
- Optimize project performance by:
  - Individual risk reduction
  - Collective contingency
- Create Risk Management Plan

7-5

Risk Management Planning
(Risk Management Plan)

- Documents specific actionable items for risks and opportunities
  - Who will manage the risk?
  - What will be done?
  - When will it be done?
  - How will it be done?
  - What resources are required?
  - What are likely benefits?

7-6

Risk Management Planning

- Learning Outcomes
- Objectives
- **Risk Management Plan Steps**
- QDOT Case Study
- Summary

7-7

Risk Management Plan (RMP) Outline

- Introduction (Purpose, Scope and Approach)
- Project Description
- Risk Identification
- Risk Assessment/Analysis
- Risk Reduction Plan
- Contingency and Recovery
- Risk Management Plan Implementation

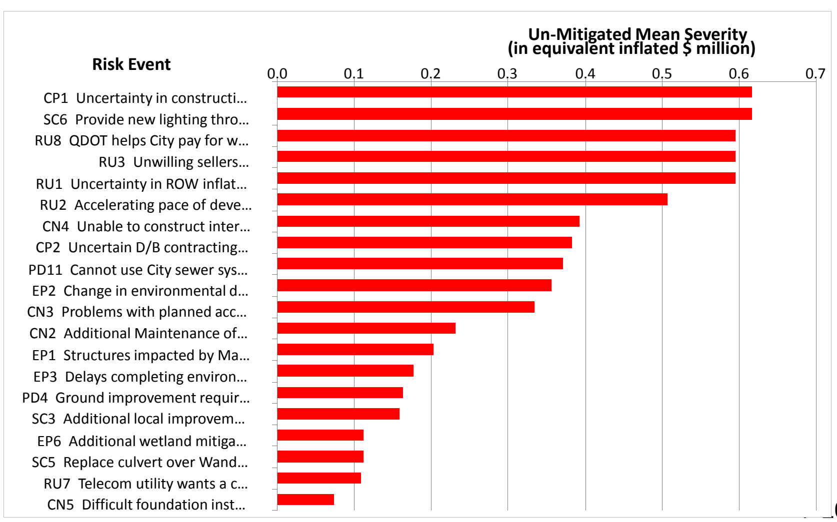
7-8

Risk Management Plan Steps

1. Identify most significant risks and opportunities
2. Identify possible assignment and actions
3. Evaluate cost-effectiveness of actions
4. Identify most cost-effective set of actions
5. Plan needed resources, including contingency to cover remaining risks

7-9

Step 1: Identify Most Significant Risks/Opportunities



Step 2: Identify Possible Assignments and Actions

- Who is best able to manage?
- What response options are available?
  - Avoid
  - Mitigate
  - Transfer
  - Accept

Risk Allocation

Allocate risks

- Before they occur
- To party best able to manage
- In alignment with project goals
- Clearly and unambiguously
- To align team and customer goals

Risk Allocation

Contractual Methods to Reduce Project Risk

- Choice of delivery method
- Choice of procurement method
- Choice of payment method
- Language of general and technical specifications

7-13

Risk Allocation

Allocation through Alternative Contracting Methods

Project Delivery Approaches

- Indefinite Quantity/Indefinite Delivery
- Const. Manager/Gen. Contractor
- Design-Build
- Design-Build-Warranty
- Design-Build-Operate-Maintain (DBOM)
- Design-Build-Operate-Maintain-Finance (DBOMF)

Procurement Approaches

- Alternative Bids/Designs
- Request for Proposals
- Cost Plus Time (A+B)
- Multi-Parameter Bidding (A+B+Q)
- Best-Value

Contract Payment Approaches

- Disincentive or Penalty Contracts
- Incentive Contracts
- Incentive/Disincentive Contracts
- Lane Rental Contracts
- No Excuse Bonus Contracts
- Lump Sum Contracts

7-14

RMP (Example Assignment & Actions) Pre-Construction Risks

Risk	Ownership	Possible Mitigation Action
Real estate acquisition delays	Owner	• Early acquisition • Early inclusion of project in area master plans to control future development
Environmental process delays	Owner	• Broad project definition • Early stakeholder involvement
Poor bid competition	Owner	• Contractor outreach • Contract packaging • Ad timing

7-15

RMP (Example Assignment & Actions) Construction Risks

Risk	Ownership	Possible Mitigation Action
Construction accidents	Contractor	• Builder's insurance • Safety program
Contractor insolvency	Owner	• Prequalification • Bonds
Unforeseen geotechnical problems	Owner	• Geotechnical baseline report (GBR) • Differing site conditions (DSC) clause

7-16

Steps for Risk Management Planning (cont.)

Step 3: Evaluate cost-effectiveness of actions

- Analyze actions individually
  - "Benefits" (effectiveness) – risk severity reduction
  - "Cost" – to implement
- Expand on identification and assessment

Step 4: Identify <u>most cost-effective set</u> of actions

Step 5: Plan resources needed including

contingency to cover remaining risks

7-17

Risk Management Planning (Contingency)

- Required for remaining (residual) risks
- Additional funds for uncertain events (unknown-unknowns)
- Needs to be right size
- Types of Contingency
  - Line item contingency
  - Bottom-line project contingency
  - Overall program contingency (reserve)

7-18

Risk Management Planning – Contingency (cont.)

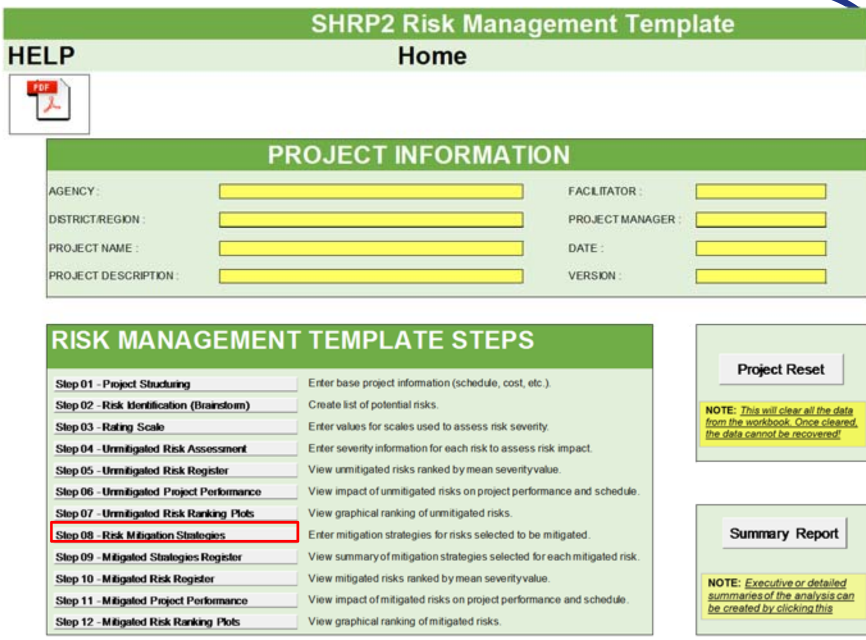
- Contingency management and resolution
  - Allocated over time to match remaining risks
  - Must be adequately tracked and managed
  - After some risks resolved, either:
    - If excess contingency, release
    - If inadequate contingency, implement recovery
  - Include in estimate (if allocated to contractors)
    - Example: An Alternate Technical Concept (ATC) could be an opportunity for project cost savings

7-19

Risk Management Planning

- Learning Outcomes
- Objectives
- Risk Management Plan Steps
- **QDOT Case Study**
- Summary

7-20



Case Study for RMP

I. Instructor demonstration using template

7-22

Case Study for RMP

II. Participants facilitate same small groups

- Select “facilitator” (periodically switch)
- Select “template input person”
- Using high ranking risks from previous module exercise
  - Identify feasible proactive risk reduction action(s)
  - Assess their implementation and effectiveness factors
- Document using risk template
- Be prepared to share results

7-23

Case Study RMP Results

1. Groups present select results
2. Instructors present “full” final template results including
   - High ranked mitigated risks:
     - Table format (step 10 of template) and
     - Risk ranking plots (step 12 of template) (tornado chart)
   - Mitigated performance results: cost, schedule, disruption (step 11 of template)

7-24

Case Study RMP Results

- QDOT RMP results illustration from MS Excel Risk Template

7-25

Risk Management Planning

- Learning Outcomes
- Objectives
- Risk Management Plan Steps
- QDOT Case Study
- **Summary**

7-26

Summary

- Proactively reduce individual risks
  - Base decision on cost-effectiveness
  - Focus on most significant risks
- Establish contingency
- Develop Risk Management Plan

7-27

Questions?

goSHRP2@dot.gov

SHRP2 SOLUTIONS

Save lives. Save money. Save time.

7-28

SHRP2 Risk Management Template

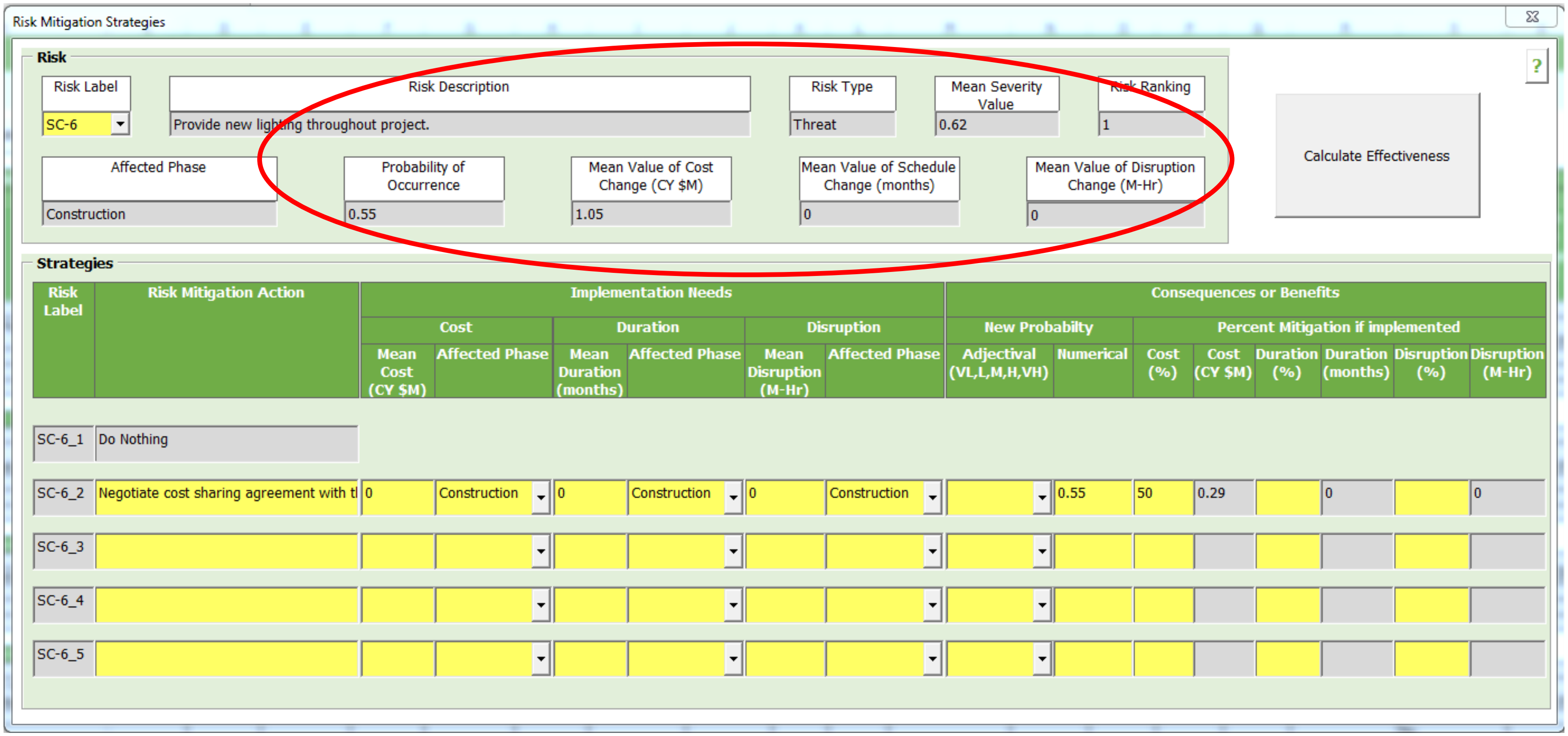
HELP

Step 08 - Risk Mitigation Strategies

Conduct Risk Mitigation | Create Registers | Clear All | <===BACK | HOME | FWD==>

Risk Mitigation Label	Risk Mitigation Actions	Implementation Needs of Risk Mitigation Actions						Consequences of Risk Mitigation Actions								Effectiveness of Risk Mitigation Actions		
		Cost		Schedule		Disruption		New Probability		Percentage Mitigated, if implemented								
		Mean Cost (CY $M)	Affected Phase	Mean Duration (months)	Affected Phase	Mean Disruption (M-Hr)	Affected Phase	Adjectival (VL, L, M, H, VH)	Numerical	Cost (%)	Mean Cost (CY $M)	Duration (%)	Mean Duration (months)	Disruption (%)	Mean Disruption (M-Hr)	Mitigated Severity (%)	Benefit/Cost Ratio	Action Selected

Course Module 7- Risk Management Planning



Helpful Definitions for Template Step 8- Risk Mitigation Strategies Interface Menu

1. Probability of Occurrence = Unmitigated Probability of Occurrence (Step 4, Column E).
2. Mean Value of Cost Change (CY $M) = Unmitigated Mean Cost Change or Unmitigated Mean Cost Assessment (Step 4, Column I)
3. Mean Value of Duration Change (months) = Unmitigated Mean Duration Change or Unmitigated Mean Duration Assessment (Step 4, Column N)
4. Mean Value of Disruption Change (Million-hours) = Unmitigated Mean Disruption Change or Unmitigated Mean Duration Assessment (Step 4, Column S)

Finally, the QDOT analysis team evaluated the project performance and schedule after taking into account the effects of risk mitigation. The mitigated project performance and schedule are depicted in Figure 1 and Figure 2.

Mitigated Project Cost, Duration, and Disruption Performance

Project Phase	Base + Implementation			Residual Risk			Total (Base + Implementation + Residual Risk)			
	Cost (CY $M)	Duration (months)	Disruption (M-hrs)	Cost (CY $M)	Duration (months)	Disruption (M-hrs)	Cost (CY $M)	Duration (months)	Disruption (M-hrs)	Cost (YOE $M)
Planning	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Scoping	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Prelim Design/Environmental Process	1.19	12.00	0.00	0.13	1.47	0.00	1.32	13.47	0.00	1.34
Environmental Permits	0.00	6.00	0.00	0.00	0.31	0.00	0.00	6.31	0.00	0.00
ROW/Util/RR	3.05	12.00	0.20	2.35	0.70	0.00	5.40	12.70	0.20	5.67
Final Design	0.20	6.00	0.00	0.00	0.75	0.00	0.20	6.75	0.00	0.21
Procurement	0.00	6.00	0.00	0.22	0.29	0.00	0.22	6.29	0.00	0.23
Construction	11.85	16.00	0.50	1.88	0.38	-0.02	13.73	16.38	0.48	14.76
Operations & Maintenance	0.00	600.00	1.40	0.00	0.00	0.00	0.00	600.00	1.40	
Replacement	0.00	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.70	
Total (through Construction)	**16.29**		**0.70**	**4.58**		**-0.02**	**20.87**		**0.68**	**22.21**
Total (through Replacement)	**16.29**		**2.80**	**4.58**		**-0.02**	**20.87**		**2.78**	**22.21**

Figure 1. Mitigated project performance (cost, duration, and disruption)

Project Schedule Performance (Unmitigated vs. Mitigated)

Project Phase	Unmitigated Project Schedule Performance (from step 6)						Mitigated Project Schedule Performance						Mean
	Duration (Months/ Date)	Early Start	Early Finish	Late Start	Late Finish	Float (months)	Duration (Months/ Date)	Early Start	Early Finish	Late Start	Late Finish	Float (months)	Severity YOE($M)
Planning	0.00	12/1/2009	12/1/2009	12/1/2009	12/1/2009	0.00	0.00	12/1/2009	12/1/2009	12/1/2009	12/1/2009	0.00	0.01
Scoping	0.00	12/1/2009	12/1/2009	12/1/2009	12/1/2009	0.00	0.00	12/1/2009	12/1/2009	12/1/2009	12/1/2009	0.00	0.58
Design Funding Date	12/1/2009		12/1/2009		12/1/2009	0.00	12/1/2009		12/1/2009		12/1/2009	0.00	0.00
Prelim Design/Environmental Process	13.47	12/1/2009	1/14/2011	12/1/2009	1/14/2011	0.00	13.47	12/1/2009	1/14/2011	12/1/2009	1/14/2011	0.00	1.18
Environmental Permits	6.31	1/14/2011	7/25/2011	2/8/2011	8/19/2011	0.81	6.31	1/14/2011	7/25/2011	1/26/2011	8/6/2011	0.39	0.07
ROW/Util/RR Funding Date	12/1/2009		12/1/2009		2/17/2012	26.59	12/1/2009		12/1/2009		2/4/2012	26.17	0.00
ROW/Util/RR	13.13	1/14/2011	2/17/2012	1/14/2011	2/17/2012	0.00	12.70	1/14/2011	2/4/2012	1/14/2011	2/4/2012	0.00	2.27
Construction Funding Date	12/1/2009		12/1/2009		2/8/2011	14.30	12/1/2009		12/1/2009		1/27/2011	13.88	0.00
Procurement	6.29	1/14/2011	8/19/2011	2/8/2011	8/19/2011	0.00	6.29	1/14/2011	8/6/2011	1/27/2011	8/6/2011	0.00	1.01
Final Design	6.75	8/19/2011	3/11/2012	8/19/2011	8/13/2012	5.10	6.75	8/6/2011	2/27/2012	8/6/2011	7/17/2012	4.63	0.00
Construction	16.85	9/18/2011	2/11/2013	9/18/2011	2/11/2013	0.00	16.38	9/5/2011	1/15/2013	9/5/2011	1/15/2013	0.00	0.20
Operations & Maintenance	600.00	2/11/2013	1/20/2063	2/11/2013	1/20/2063		600.00	1/15/2013	12/24/2062	1/15/2013	12/24/2062		
Replacement	0.00	1/20/2063	1/20/2063	1/20/2063	1/20/2063		0.00	12/24/2062	12/24/2062	12/24/2062	12/24/2062		
Project Start Date	**12/1/2009**						**12/1/2009**					Total	5.33
Construction Finish Date	**2/11/2013**						**1/15/2013**						
Project Duration (months)	**38.45**						**37.55**						

Figure 2. Mitigated project schedule

Simplified Risk Management Planning Demonstration Workshop For PRHTA Bridge 702/PR-681

SHRP2 R09

WORKSHOP PROCEEDINGS SUMMARY

for
FHWA/Puerto Rico Highway & Transportation Authority

by

Demonstration Workshop Facilitators:
Mr. Jerry DiMaggio, Applied Research Associates, Inc.
Mr. Paul Dalbey, Applied Research Associates, Inc.

February 2-3, 2016

Table of Contents

List of Figures

List of Tables

Attachments

ATTACHMENT A – Project Related Documentation

- Attachment A-1: Project Description Form
- Attachment A-2: Project Layout Map
- Attachment A-3: Project Overview Presentation
- Attachment A-4: Abbreviated Project Schedule
- Attachment A-5: Overall Project Schedule

ATTACHMENT B – Completed R09 Template

ATTACHMENT C – Pre-Workshop Documentation

- Attachment C-1: 1-Hour Conference Call (11-13-15) Agenda
- Attachment C-2: 1-Hour Conference Call (11-13-15) Minutes
- Attachment C-3: 3-Hour Preparation Webinar (12-03-15) Agenda
- Attachment C-4: 3-Hour Pre-Demonstration Workshop Webinar-Presentation & Speaker Notes
- Attachment C-5: 3-Hour Pre-Demonstration Workshop Webinar- Minutes
- Attachment C-6: FHWA SHRP2 R09 Demonstration Workshop (02-02-16 to 02-03-16) Agenda
- Attachment C-7: FHWA SHRP2 R09 Demonstration Workshop (02-02-16 to 02-03-16) Attendee List

EXECUTIVE SUMMARY

The Puerto Rico Highway and Transportation Authority (PRHTA) is planning to replace Bridge 702 over Caño Tiburones near the city of Arecibo along PR-681. The bridge, originally designed in 1952 and built between 1953 and 1955, is in fair overall condition but showing signs of deterioration, particularly in the superstructure. This project is of vital importance to the local community as Bridge 702 is the only access to Barrio Islote in Arecibo for the 10,000 residents of Barrio Islote. The other access is through PR-681 to Barceloneta and Express Way PR-22 which is a 20-km route and approximately 30 minutes of travel.

Multiple options for reconstruction have been considered and evaluated, including upstream and downstream replacement and rehabilitation of the existing structure. Due to the complexities of maintaining access to the bridge during construction, complete reconstruction was considered non-optimal. The upstream replacement option was deemed preferable due to the proximity of a nearby marina (located downstream) and the desire of the local community to raise the vertical profile of the bridge to better accommodate local fisherman accessing the Puerto Arecibo from the Caño Tiburones.

The project is being let as a traditional Design-Bid-Build (DBB). To improve and control ultimate project performance where innovative methods are being used, PRHTA conducted formal risk management, as described in the "Guide for Managing Risks for Rapid Renewal Projects" (TRB, 2010). Such risk management involves appropriately anticipating and planning for potential problems (risks), as well as opportunities (negative risks) and is documented in this project *Risk Management Plan.*

This *Risk Management Pla*n consists of the following elements:

- Description of the project
- Identification of current risks (including threats and opportunities), and assessment of their factors
- Analysis of project performance, and ranking of risks in terms of their contribution to this project performance
- Identification of ways to proactively reduce significant individual risks (including threats and opportunities, and evaluation of their cost-effectiveness
- Selection, planning and implementation of cost-effective ways to proactively reduce significant individual risks (threats) and exploit key opportunities
- Establishment of organizational structure and resources to successfully implement the *Risk Management Plan.*

The above elements were completed using a simplified approach via a facilitated workshop in San Juan, PR, on February 2-3, 2016, which was preceded by significant preparations. During the workshop, a total of 37 risks (including threats and opportunities) were identified, evaluated, and prioritized. The top ten (10) risks (including threats and opportunities) were assessed in more detail and addressed by risk reduction planning.

The key results from the risk management process are summarized in Table ES.0.1.

Table ES.0.1. Summary of Risk Management Results

Project Performance Measures	Unescalated Cost (CY $M)	Escalated Cost (YOE $M)	Construction NTP Date	Construction Completion Date	Construction Duration (months)
Base (w/out risk)	3.07	3.30	8/21/2017	2/20/2019	18.00
Unmitigated (Base + Risk)	4.24	4.67	5/17/2018	2/27/2020	21.41
Mitigated (Base +Implementation + Residual Risk)	3.53	3.82	10/4/2017	5/28/2019	19.77

FHWA and AASHTO hope that the PRHTA participants developed an understanding of the R09 simplified risk management process and can see its value on other PRHTA projects, particularly since PRHTA staff should be able to implement this process internally.

FHWA and AASHTO suggest early implementation of the R09 risk management process during project design and before the environmental process (e.g., NEPA) is finalized. It is also suggested that the R09 risk management process be coordinated with the value engineering program. These processes would strongly complement each other from project identification through alternatives analysis.

1 INTRODUCTION

1.1 Purpose and Objectives

The primary purpose of this Risk Management Plan is to provide appropriate plans (and adequate justification of those plans) for improving and controlling "performance" (i.e., cost, schedule, disruption, and longevity) of the project by focusing on controlling project risks (both individually and collectively)

Quantification of the uncertainty in project performance, e.g., to help establish budgets, milestones, and contingencies at PRHTA-specified confidence levels, is not currently part of the scope of this Risk Management Plan, but could be added later.

A demonstration workshop was conducted for PRHTA's Bridge 702/PR-681 reconstruction project to demonstrate the risk management process by applying it to the project. In preparation for the workshop, a 1-hour conference call (held November 13, 2015) and a 3-hour webinar (held December 3, 2015) were conducted. Documentation of pre-workshop activities is provided in Attachment C. The purpose and objectives of the demonstration workshop (held February 2 and 3, 2016) were to:

- Identify, assess, evaluate, and rank all significant project "performance" (i.e., schedule and cost) risks
- Identify, evaluate, select and plan actions to cost effectively reduce key risks (threats) and exploit key opportunities to improve project performance
- Provide mitigated performance estimates to help establish appropriate contingencies

1.2 Approach

The approach taken in developing this plan is adopted from "Guide for Managing Risks for Rapid Renewal Projects" (TRB, 2010). This approach consists of the following steps, as documented in this plan:

- Project Description (Section 2) - Develop an adequate understanding of the project (as documented in a specific format) and its likely "base" (without "risk") performance (i.e., regarding schedule, cost, and disruption through construction, and post-construction longevity). As part of this, develop a simple but adequate cost- and disruption-loaded project schedule. **(Note that disruption and longevity were not considered for the Bridge 702/PR-681 project).**
- Pre-Mitigation Risk Identification and Assessment (Section 3) – Develop a comprehensive and non-over-lapping set of project performance risks (threats and opportunities), which are possible events that, if they occur, can change project performance and categorize the list by when during project development the risks would occur. For each of the risks, adequately assess the factors defining those risks, including the likely impacts (e.g., change in unescalated cost to a particular project activity) if the risk occurs and the likelihood of the event (as defined by those impacts) occurring.
- Pre-Mitigation Risk Analysis (Section 4) – Determine likely project performance, including the risks, and especially the relative significance of the various risks in affecting that performance ("sensitivity"), before any mitigation.
- Risk Mitigation Planning (Section 5) – Identify possible actions to proactively reduce individual risks (threats) and exploit key opportunities, focusing on the most significant

risks (threats and opportunities), and evaluate their cost- effectiveness. Select and adequately plan (i.e., assign responsibility and resources) the set of cost-effective mitigation actions.

- Post-Mitigation Risk Analysis (Section 6) – Determine likely project performance, including the risks, and especially the relative significance of the various risks in affecting that performance (“sensitivity”), considering mitigation.
- Contingency Management (Section 7) – Establish contingency requirements (cost and schedule allowances) for the various phases of project development, based on likely project performance considering collectively the residual risks for each phase if the risk mitigation plans are adopted and implemented. Also establish adequate procedures for how those contingencies will be controlled.
- Risk Management Plan Implementation (Section 8) – Identify the organizational structure and resources required to successfully implement this Risk Management Plan.
- Conclusions (Section 9): Establish a formal set of actions to implement and monitor the Risk Management Plan.

Each of the above steps is briefly discussed in the following sections, with details presented in attachments (including the completed risk management template in **Attachment B**).

A copy of the R09 Risk Management overview presentation that was presented to PRHTA by the risk facilitator can be found in **Attachment C**.

2 PROJECT DESCRIPTION

2.1 Project Summary

This project will replace the existing Bridge 702 near the intersection of PR-681 and PR-655. The existing two-lane bridge was designed around 1952 and built between 1953 and 1955. It carries PR-681 over the Caño Tiburones near Ciénaga Tiburones, a state nature wildlife preserve. The current structure is in fair condition but showing conditions of deterioration. The last inspection report from 2013 indicated the bridge had a superstructure rating of 4.

Work on this bridge is under particular public scrutiny because it serves as the only link between the municipality of Arecibo and the 10,000 residents of Barrio Islote for nearly 20 km. The other access to Barrio Islote is through PR-681 from the Municipality of Barceloneta which is approximately 20 km away and approximately 30 minutes of travel time.

As part of the preliminary engineering for this project, several rehabilitation and replacement options were considered. The three main options were as follows:

- In-place rehabilitation of the existing bridge. Rehabilitation efforts on the existing bridge would require a full closure, thereby requiring a temporary bridge to be built adjacent to the existing bridge. This temporary bridge would cost nearly the same amount of money and require the same environmental permitting process as a permanent bridge. This option was discarded near the beginning of the process.
- Downstream replacement of bridge. This option would have a new bridge constructed immediately downstream (northwest) of the existing bridge. Because of the geometry of the Caño Tiburones, the bridge would be significantly longer and more costly. Additionally, the bridge and necessary right-of-way would encroach upon and require acquisition of land from the existing marina on the northwest quadrant of the project. As a result of these issues, the downstream replacement of the bridge was considered a less desirable option.
- Upstream replacement of bridge. This option would provide a new bridge meeting all current codes and specification immediately upstream (southeast) of the existing bridge. This option would allow the bridge to be built on existing embankments that were used for a bridge prior to the construction of the existing 1955 structure. Environmental impacts would be minimal within this option, and redesign of the PR-681/655 intersection as a result of the bridge realignment will allow for significant safety improvements. **This is the preferred design alternative**.

The project is currently at the 15% design stage. The project scope includes:

- Replacement of the existing Bridge 702 with a structure that meets all current PRHTA and FHWA codes and specifications. The replacement bridge is likely to be constructed immediately adjacent to the existing bridge to the southeast.
- The replacement bridge will have a greater vertical clearance to meet the request of local citizens and fishermen. The existing bridge is too low for local fisherman to safely pass underneath, especially during times of high tide.
- Relocation of all utilities currently crossing the existing bridge to the new bridge. Utilities include overhead power lines, communication cables, and a diesel fuel line that supplies power from a local power plant.
- Realignment of PR-681 to access the new shifted bridge.
- Reconfiguration of the intersection of PR-681 and PR-655.

- Removal of existing bridge and mitigation of embankments to useable green space.

Funding for the project is being sourced through the FHWA Critical Bridges program.

The project will be constructed in three phases and use a traditional Design-Bid-Build (DBB) procurement. The first phase of the project will cover the construction of the new bridge. Phase two includes permanently relocating all utilities, constructing the new alignment necessary to access the new bridge, and reconfiguration of the PR-681/655 intersection immediately northeast of the new bridge. Phase three will consist of removing the existing bridge and converting the existing embankments into usable space for the local community.

Major construction work is expected to begin in summer 2017 and continue into early 2019.

The **R09 Project Description form** was completed prior to the 3-hour webinar and it includes additional information about the project. This form and other project supporting materials, including major assumptions and conditions, are included in **Attachment A**.

Base schedule and costs detailed in the sections below were calculated based on information provided during preparation for the demonstration workshop. Additional refinements were discussed and accepted during the workshop. Updates to cost and schedule can and should be made by the project team as the project progresses through its later phases.

2.2 Project Schedule

The project schedule information provided by the project team is as follows:

- Phase 1 – Construction of the new bridge adjacent to and immediately southeast of the existing Bridge 702.
- Phase 2 – Relocate all utilities to the new bridges, construct new approach pavements, and reconfigure intersection of PR-681 and PR-655 to northeast of bridge.
- Phase 3 – Move traffic onto new bridge, remove existing bridge, and convert existing embankments into usable public space.
- **Attachment A** includes the PRHTA latest design schedule and abbreviated construction schedule.

PRHTA anticipates Construction Contractor Notice to Proceed (NTP) to be issued on or around August 21, 2017. Construction duration is expected to last 18 months, finishing on or around February 20, 2019.

Discussions during the workshop also revealed that the time required to complete the ROW/Utilities/RR phases is approximately two months after funding for that phase has been received (this is noted in Step 1 of the R09 Risk Template as *Lag E*). This was of little significance for this project because the ROW/Utilities/RR Funding was assumed to have been secured at the start of the project (August 5, 2015). As such, the funding date was not the controlling factor for ROW/Utilities/RR phase beginning and end dates. If funding has not to date been secured, a re-evaluation of this Lag may be necessary to determine if a delay to the ROW/Utilities/RR end date will occur.

2.2.1 Base schedule (abstracted schedule)

As presented in Table 2.1 (Step 1 of R09 Risk Template), for the assumptions outlined above, the “base” project schedule (without risk) was developed from PRHTA’s latest design schedule and construction abbreviated schedule, using a standard simplified project flowchart for DBB (shown in schematic form in Figure 2.1) with base durations, lags, and milestones for the various activities (see Figure 2.1). PRHTA’s project schedule was first reviewed and “de-biased”, removing any float. In general terms of overall pre-construction and construction schedules, the base project schedule (without risk and opportunity) was 24.6 months from the project start date (August 5, 2015) to reach construction contractor NTP (August 21, 2017), then 18 months for construction, with a target completion date of February 20, 2019. The pre-construction schedule estimate includes a 6-month duration for project procurement.

Table 2.1. Base Project Information (without risks)

SUMMARY					
Project Phase	Total CY Cost ($M)	Total YOE Cost ($M)	Duration (months)	Early Start	Early Finish
Planning		0.00	0	8/5/2015	8/5/2015
Scoping		0.00	0	8/5/2015	8/5/2015
Design/Environmental Process	0.24	0.24	13.6	8/5/2015	9/21/2016
Environmental Permits	0.28	0.29	0	9/21/2016	9/21/2016
ROW/Util/RR		0.00	0	9/21/2016	9/21/2016
Final Design		0.00	5	9/21/2016	2/20/2017
Procurement		0.00	6	2/20/2017	8/21/2017
Construction	2.55	2.77	18	8/21/2017	2/20/2019
Operations & Maintenance					
Replacement					
Base Cost (YOE $M)	3.30	(through Operations, Maintenance, & Replacement)			
Base Construction Completion Date	2/20/2019				
Months to Construction Completion	42.60				
Base Disruption ($M)	0.00	(through Operations, Maintenance, & Replacement)			

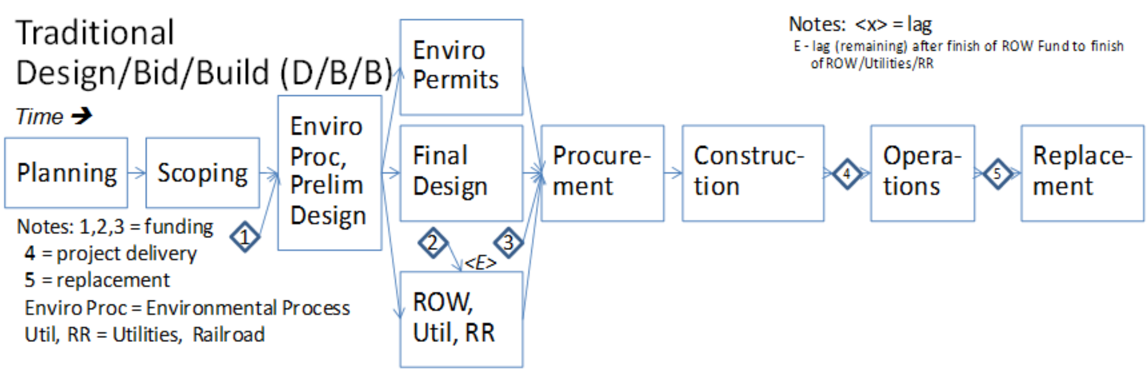


Figure 2.1. Overview of Traditional Design-Bid-Build delivery process

2.3 Project Cost

The preliminary cost estimate provided by PRHTA is presented below. Because the project is still in its early design stages (approximately the 15% complete stage), cost estimates are not well broken down and do not currently have good granularity. Key assumptions related to PRHTA's cost estimate are summarized below. These costs were prepared in December 2015 and are based on information provided by Atkins Caribe and PRHTA.

- Construction costs: $2,710,528
- Internal PRHTA overhead: $216,842 (assumed to be 8% of construction costs)
- Engineering and design: $518,000
- Total costs: $3,445,370

Liquidated damages are estimated to be $2,000 per day, of $60,000 per month.

Relocation of water and power utilities is to be included in the cost of the construction contract. All other utilities that cross the existing bridge will be moved at the utility owner's expense and are therefore not accounted for in the contract cost estimate.

2.3.1 Base cost (abstracted cost)

For the assumptions outlined above, the "base" project cost (without risk) was developed from PRHTA's latest cost estimate and allocated to the activities in the DBB standard simplified project flowchart, to create a simple cost-loaded schedule (Table 2.1). PRHTA's project cost estimate was first reviewed and de-biased, removing any contingency. The base total project cost (through delivery, removing all contingency) is approximately $3.068 million in 2016 (un-inflated) dollars. By major project component or phase, the base costs (in current un-inflated dollars) are approximately as follows:

- $281,000 for design and engineering. This value also includes placeholder values for planning and scoping that were not otherwise separated.
- $237,000 for environmental studies and permitting.
- $2.550 million for construction.

Note that these values were revised slightly at the demonstration workshop and are slightly different than the original base estimate costs shown in Section 2.3. Additional update can and should be made by the project team as the project progresses.

Prior to the demonstration workshop, the estimated overhead rate for PRHTA was disclosed as 8% of the estimated construction cost, or approximately $204,000. However, during the workshop, it was discussed that the overhead rate was considered a sunk cost of doing business and not an additional project expense unless project delays required overhead expenses beyond the planned project duration. Those mean extended overheads (i.e., delay costs) associated with schedule delays are about $50,000 per month for pre-construction and about $100,000 per month during construction, based on average "burn rates".

On average, mean Inflation is about 3.0% per year for preconstruction engineering, 3.0% per year for ROW and 3.0% per year for construction.

2.4 Project Disruption

Project disruption was not considered for the Bridge 702 project since the PRHTA was not interested in including this performance measure in the risk analysis.

2.5 Tradeoffs

As part of the risk management process, “tradeoffs” may be established for the purpose of combining performance (cost, disruption, schedule, and longevity): The “value” (or user costs) of disruption (in terms of how much PRHTA would be willing to pay now to avoid disruption) could be established in terms of dollars per person-hour. Additionally, the value of the planned completion date (in terms of how much PRHTA would be willing to pay now to prevent delay) could be established in terms of dollars per month. **However, tradeoffs were not considered in this workshop. They could be considered in future workshop is desired by PRHTA**.

2.6 Base Project Performance Analysis

As presented in Table 2.1, the following mean base project performance measures were determined (using the R09 Risk Template) based on the DBB standard simplified project flowchart using mean input values (as discussed above):

- Mean base project cost through construction (unescalated) – $3.068 M (February 2016 $)
- Mean base project cost through construction (escalated) – $3.305 M (YOE$)
- Mean project construction completion date – 2/20/2019

It should be noted that the mean base performance produced by full probabilistic risk analysis might differ from that produced by the R09 Risk Template for several reasons: a) the full probabilistic risk analysis is typically done in more detail; and b) the means of the input ranges used in full probabilistic risk analysis might differ from the directly assessed mean inputs used in the R09 Risk Template.

3 RISK IDENTIFICATION AND ASSESSMENT – BEFORE MITIGATION

In a facilitated environment, the project team and project-independent subject matter experts identified a comprehensive, non-overlapping set of risks and opportunities relative to the project "base", first by brainstorming and then by categorizing/editing/adding. Some of the risks identified were having the initial environmental access requirement turn into a complete environmental impact study, approval of environmental permits by the US Army Corps of Engineers taking longer than anticipated, damage to the marina wall during construction, access to additional funding in case of overruns, and public opposition to a new horizontal alignment, among others. Some of the opportunities (negative risks) identified were the possibility of aggressive bidding driving down prices and possibility of savings due to innovative construction techniques. The risks were then categorized by project development phase, which is summarized in Table 3.1 (Step 2 of R09 Risk Template). The numbers of risks identified, by development phase, were: ten (10) under Preliminary Design/Engineering, three (3) under Environmental Permit, one (1) under Construction Funding, one (1) under Procurement and twenty-two (22) under Construction for a total of 37 risks.

Table 3.1. Initial Risks

Risk Label	Description of Risk Table Below Fills by Selecting "Create List of Risks" Button Above	Project Phase	Retire Risk?
PD-1	Relocation of food truck vendors	Prelim Design/Environmental Process	No
PD-2	Enivro assessment turns into EIS requirement	Prelim Design/Environmental Process	No
PD-3	Public opposition to horizontal alignment	Prelim Design/Environmental Process	No
PD-4	Public request for additional vertical clearance	Prelim Design/Environmental Process	No
PD-5	Existing rails found to be historical	Prelim Design/Environmental Process	No
PD-6	Rejection of HH study by DNR	Prelim Design/Environmental Process	No
PD-7	Public opposition to disturbance of wetlands	Prelim Design/Environmental Process	No
PD-8	Municipality requests area of existing bridge turned to recreational area	Prelim Design/Environmental Process	No
PD-9	Litigous culture of contractors	Prelim Design/Environmental Process	No
PD-10	Components of existing bridge deemed historical	Prelim Design/Environmental Process	No
EP-1	More wetland mitigation required than planned	Environmental Permits	No
EP-2	Finding place to replace affected trees, may require additional ROW	Environmental Permits	No
EP-3	USACOE Permit longer than anticipated	Environmental Permits	No
F3-1	Lead paint removal is non-participating	Construction Funding	No
PR-1	Aggressive bidding brings costs down	Procurement	No
CR-1	Rupture of existing diesel line during consturction	Construction	No
CR-2	Innovation in construction techniques brings costs down	Construction	No
CR-3	Existing bridge require premature closure/restrictions	Construction	No
CR-4	Enivro condition due to pile driving (vibrations vs soil)	Construction	No
CR-5	Damage to marina wall during destruction of abutment	Construction	No
CR-6	Extreme weather events/hurricane	Construction	No
CR-7	Construction noise effect on wildlife	Construction	No
CR-8	Limited construction timeframe (daily basis), MOT	Construction	No
CR-9	Limited construction staging area for contractor	Construction	No
CR-10	Moving of overhead lines takes longer than expected	Construction	No
CR-11	Moving of high voltage power lines takes longer than expected	Construction	No
CR-12	Restrictions from biological assessment limit construction times	Construction	No
CR-13	Only one contractor to build box beams	Construction	No
CR-14	Relocation of underground utilities affects MOT	Construction	No
CR-15	MOT during adjustment of grade	Construction	No
CR-16	Additional subgrade preperation for piles/pavement	Construction	No
CR-17	Transportation of materials	Construction	No
CR-18	Fisherman under new bridge during construction	Construction	No
CR-19	Competition from another pre-cast manufacturer	Construction	No
CR-20	Access to additional funding in case of overruns	Construction	No
CR-21	Violation of permit conditions	Construction	No
CR-22	Rock slope instability	Construction	No

These risks to project cost and schedule were documented in the “risk register”. Each risk and opportunity is defined by several “risk factors”:

- the cost and duration changes to specific project activities (i.e., the “impact scenario”) if the risk occurs; and
- the probability of occurrence (as defined by the impact scenario), recognizing that the chance that the risk event does not occur (i.e., no impacts) equals 1.0 minus the probability of occurrence.

The group (by consensus) characterized each of these risk factors in a “mean-value” (i.e., probability-weighted average) sense, via either mean values (e.g., in dollars and months) or pre-defined mean risk ratings (e.g., H, M, L). The facilitators introduced the generic rating values and percentages (cost, schedule, disruption and probability) to the workshop participants. The participants were provided an opportunity to adjust the percentages or maintain the default template values. The respective quantitative values (low and high ranges) were established based on the base cost and schedule. Each input was established using a Delphi Technique approach which applies the body of knowledge of experts (the project team members) and then the template equations use the input values to establish the severity. These factor assessments were also documented in the risk register. Definitions for the risk-factor rating scales (taken from the R09 template) are presented in Table 3.2 (Step 3 of R09 Risk Template).

Table 3.2. Risk Factor Rating Scales

COST CHANGE

Adjectival Rating	Percent of Base Cost		Absolute Value (CY $M)		Expected Mean Value	
	Low	High	Low	High	Percent	Absolute
VH	25.00	100.00	0.77	3.07	62.50	1.92
H	10.00	25.00	0.31	0.77	17.50	0.54
M	3.00	10.00	0.09	0.31	6.50	0.20
L	1.00	3.00	0.03	0.09	2.00	0.06
VL	0.00	1.00	0.00	0.03	0.50	0.02

DURATION CHANGE

Adjectival Rating	Percent of Base Schedule		Absolute Value (months)		Expected Mean Value	
	Low	High	Low	High	Percent	Absolute
VH	28.17	56.34	12.00	24.00	42.25	18.00
H	9.39	28.17	4.00	12.00	18.78	8.00
M	2.35	9.39	1.00	4.00	5.87	2.50
L	0.59	2.35	0.25	1.00	1.47	0.63
VL	0.00	0.59	0.00	0.25	0.29	0.13

PROBABILITY OF OCCURRENCE

Adjectival Rating		Probability Range	Mean Probability
	Low	High	
VH	0.70	1.00	0.85
H	0.40	0.70	0.55
M	0.20	0.40	0.30
L	0.05	0.20	0.13
VL	0.00	0.05	0.03

Table 3.3 (Step 4 of the R09 Risk Template) presents the risk register, in terms of a categorized list of risks (from the R09 Risk Template) that has been edited and added to so that the list is comprehensive and non-overlapping, and their mean-value or mean rating factor assessments before mitigation (from the R09 Risk Template).

Note that a mean-rating or mean-value risk assessment approach (as used here) provides single mean values/ratings of project performance, essentially ignoring uncertainties and correlations among those uncertainties. To more formally address such uncertainties and correlations and to produce ranges (probability distributions) rather than single mean values, a full probabilistic risk analysis would be required.

Table 3.3. Unmitigated Risk Register (Unmitigated Risk Assessment)

SHRP2 Risk Management Template

HELP **Step 04 - Unmitigated Risk Assessment**

Conduct Risk Assessment | Calculate Mean Severity Values | Clear All | <=== BACK | HOME | FWD===>

Risk Label	Risk Description	Probability of Occurrence			Mean Cost Change (CY $M)					Mean Duration Change (months)				
		Adjectival	Numerical	Mean Value	Risk Type	Adjectival	Numerical	Mean Value	Affected Phase	Risk Type	Adjectival	Numerical	Mean Value	Affected Phase
PD-1	Relocation of food truck vendors	VH		0.85	Threat		0.00	0.00		Threat	VL		0.13	ROW/Util/RR
PD-2	Enivro assessment turns into EIS requirement	M		0.30	Threat	VL		0.02	Prelim Design/Environn	Threat	VH		18.00	Prelim Design/Environm
PD-3	Public opposition to horizontal alignment	L		0.13	Threat		0.00	0.00		Threat	VL		0.13	Prelim Design/Environm
PD-4	Public request for additional vertical clearance	H		0.55	Threat	L		0.07	Prelim Design/Environn	Threat	VL		0.13	Prelim Design/Environm
PD-5	Existing rails found to be historical	L		0.13	Threat	VL		0.02	Prelim Design/Environn	Threat	H		8.00	Prelim Design/Environm
PD-6	Rejection of HH study by DNR	H		0.55	Threat		0.00	0.00		Threat	M		2.50	Prelim Design/Environm
PD-7	Public opposition to disturbance of wetlands	M		0.30	Threat	M		0.23	Construction	Threat	M		2.50	Construction
PD-8	Municipality requests area of existing bridge turned to recreational area	H		0.55	Threat	VL		0.02	Construction	Threat	VL		0.13	Construction
PD-9	Litigous culture of contractors	M		0.30	Threat	M		0.23	Construction	Threat	L		0.63	
PD-10	Components of existing bridge deemed historical	VL		0.03	Threat	VL		0.02	Construction	Threat	VL		0.13	Construction
EP-1	More wetland mitigation required than planned	VL		0.03	Threat	L		0.07	Construction	Threat	L		0.63	Construction
EP-2	Finding place to replace affected trees, may require additional ROW	VL		0.03	Threat	VL		0.02	Construction	Threat		0.00	0.00	
EP-3	USACOE Permit longer than anticipated	H		0.55	Threat		0.00	0.00		Threat		8.00	8.00	Prelim Design/Environm
F3-1	Lead paint removal is non-participating	VH		0.85	Threat	L		0.07	Construction	Threat		0.00	0.00	
PR-1	Aggressive bidding brings costs down	H		0.55	Opportunity	M		-0.23	Construction	Opportunity			0.00	
CR-1	Rupture of existing diesel line during consturction	L		0.13	Threat	VL		0.02	Construction	Threat	M		2.50	Construction
CR-2	Innovation in construction techniques brings costs down	VL		0.03	Opportunity	L		-0.07	Construction	Opportunity		0.00	0.00	Construction
CR-3	Existing bridge require premature closure/restrictions	L		0.13	Threat	L		0.07	Construction	Threat			0.00	
CR-4	Enivro condition due to pile driving (vibrations vs soil)	M		0.30	Threat	L		0.07	Construction	Threat	L		0.63	Construction
CR-5	Damage to marina wall during destruction of abutment	H		0.55	Threat	VL		0.02	Construction	Threat	VL		0.13	Construction
CR-6	Extreme weather events/hurricane	L		0.13	Threat	M		0.23	Construction	Threat	M		2.50	Construction
CR-7	Construction noise effect on wildlife	L		0.13	Threat	L		0.07	Construction	Threat	L		0.63	Construction
CR-8	Limited construction timeframe (daily basis), MOT	L		0.13	Threat			0.00		Threat	L		0.63	Construction
CR-9	Limited construction staging area for contractor	M		0.30	Threat	L		0.07	Construction				0.00	
CR-10	Moving of overhead lines takes longer than expected	L		0.13	Threat			0.00		Threat	L		0.63	Construction
CR-11	Moving of high voltage power lines takes longer than expected	M		0.30	Threat	M		0.23	Construction	Threat	M		2.50	Construction
CR-12	Restrictions from biological assessment limit construction times		0.00	0.00			0.00	0.00		Threat		0.00	0.00	
CR-13	Only one contractor to build box beams	VL		0.03	Threat	L		0.07	Construction	Threat	M		2.50	Construction
CR-14	Relocation of underground utilities affects MOT	VL		0.03	Threat	VL		0.02	Construction	Threat	L		0.63	Construction
CR-15	MOT during adjustment of grade	H		0.55	Threat	L		0.07	Construction	Threat	L		0.63	Construction
CR-16	Additional subgrade preperation for piles/pavement	L		0.13	Threat	M		0.23	Construction	Threat	M		2.50	Construction
CR-17	Transportation of materials		0.00	0.00	Threat	VL		0.02	Construction	Threat	VL		0.13	Construction
CR-18	Fisherman under new bridge during construction	H		0.55	Threat	VL		0.02	Construction				0.00	
CR-19	Competition from another pre-cast manufacturer	VL		0.03	Opportunity	VL		-0.02	Construction				0.00	
CR-20	Access to additional funding in case of overruns	H		0.55	Threat	L		0.07	Construction	Threat	M		2.50	Construction
CR-21	Violation of permit conditions	L		0.13	Threat	VL		0.02	Construction	Threat	M		2.50	Construction
CR-22	Rock slope instability	L		0.13	Threat	M		0.23	Construction	Threat	M		2.50	Construction

4 RISK ANALYSIS – BEFORE MITIGATION

The base performance factors and the risk factors before mitigation were appropriately combined (using the R09 Risk Template) to determine the following:

- Approximate mean values of base plus risk project performance before any mitigation, including:
    - o Project schedule (duration, start and end dates, and float by activity, and key milestone dates)
    - o Project cost (unescalated and escalated) by activity and collectively
    - o Project combined performance (combination of escalated project cost and schedule through construction).
- Mean "severity" of each risk, in terms of its contribution to mean combined project performance before any mitigation, and ranking of risks on that basis. Severity is the combined effect of the probability of occurrence and the impacts to cost, schedule, and disruption (when applicable).

The unmitigated base plus risk project performance (unmitigated performance) is presented in Table 4.1 (Step 6 of the R09 Risk Template). It should be noted that these mean values of project performance are very approximate (for various reasons) and should be used with caution. More accurate results would require a full probabilistic risk analysis, which is outside the scope of this Risk Management Plan.

Table 4.1. Unmitigated Base Plus Risk Project Performance (Unmitigated Performance)

Unmitigated Project Cost, Duration, and Disruption Performance

Project Phase	Base			Risk			Total (Base + Risk)			
	Cost (CY $M)	Duration (months)	Disruption (M-hrs)	Cost (CY $M)	Duration (months)	Disruption (M-hrs)	Cost (CY $M)	Duration (months)	Disruption (M-hrs)	Cost (YOE $M)
Planning		0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Scoping		0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Prelim Design/Environmental Process	0.24	13.6	0.00	0.04	8.83	0.00	0.28	22.43	0.00	0.29
Environmental Permits	0.28	0	0.00	0.00	0.00	0.00	0.28	0.00	0.00	0.30
ROW/Util/RR		0	0.00	0.00	0.11	0.00	0.00	0.11	0.00	0.00
Final Design		5	0.00	0.00	0.00	0.00	0.00	5.00	0.00	0.00
Procurement		6	0.00	0.44	0.00	0.00	0.44	6.00	0.00	0.48
Construction	2.55	18	0.00	0.69	3.41	0.00	3.24	21.41	0.00	3.61
Operations & Maintenance			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Replacement				0.00		0.00	0.00	0.00	0.00	
Total	**3.07**		**0.00**	**1.17**		**0.00**	**4.24**		**0.00**	**4.67**

Project Schedule Performance (Base vs. Unmitigated)

Project Phase	Base Project Schedule Performance						Unmitigated Project Schedule Performance						Mean Severity YOE ($M)
	Duration (Months/Date)	Early Start	Early Finish	Late Start	Late Finish	Float (months)	Duration (Months / Date)	Early Start	Early Finish	Late Start	Late Finish	Float (months)	
Planning	0.00	8/5/2015	8/5/2015	8/5/2015	8/5/2015	0.00	0.00	8/5/2015	8/5/2015	8/5/2015	8/5/2015	0.00	0.00
Scoping	0.00	8/5/2015	8/5/2015	8/5/2015	8/5/2015	0.00	0.00	8/5/2015	8/5/2015	8/5/2015	8/5/2015	0.00	0.00
Design Funding Date	8/5/2015		8/5/2015		8/5/2015	0.00	8/5/2015		8/5/2015		8/5/2015	0.00	0.00
Prelim Design/Environmental Process	13.60	8/5/2015	9/21/2016	8/5/2015	9/21/2016	0.00	22.43	8/5/2015	6/16/2017	8/5/2015	6/16/2017	0.00	0.76
Environmental Permits	0.00	9/21/2016	9/21/2016	2/20/2017	2/20/2017	5.00	0.00	6/16/2017	6/16/2017	11/15/2017	11/15/2017	5.00	0.27
ROW/Util/RR Funding Date	8/5/2015		8/5/2015		12/21/2016	16.60	8/5/2015		8/5/2015		9/16/2017	25.43	0.00
ROW/Util/RR	0.00	9/21/2016	9/21/2016	2/20/2017	2/20/2017	5.00	0.11	6/16/2017	6/20/2017	11/12/2017	11/15/2017	4.89	0.00
Final Design	5.00	9/21/2016	2/20/2017	9/21/2016	2/20/2017	0.00	5.00	6/16/2017	11/15/2017	6/16/2017	11/15/2017	0.00	0.06
Construction Funding Date	8/5/2015		8/5/2015		2/20/2017	18.60	8/5/2015		8/5/2015		11/15/2017	27.43	-0.12
Procurement	6.00	2/20/2017	8/21/2017	2/20/2017	8/21/2017	0.00	6.00	11/15/2017	5/17/2018	11/15/2017	5/17/2018	0.00	0.00
Construction	18.00	8/21/2017	2/20/2019	8/21/2017	2/20/2019	0.00	21.41	5/17/2018	2/27/2020	5/17/2018	2/27/2020	0.00	0.83
Operations & Maintenance	0.00	2/20/2019	2/20/2019	2/20/2019	2/20/2019		0.00	2/27/2020	2/27/2020	2/27/2020	2/27/2020		
Replacement	0.00	2/20/2019	2/20/2019	2/20/2019	2/20/2019		0.00	2/27/2020	2/27/2020	2/27/2020	2/27/2020		
Project Start Date	**8/5/2015**						**8/5/2015**					**Total**	1.80
Construction Finish Date	**2/20/2019**						**2/27/2020**						
Project Duration (months)	**42.60**						**54.84**						

The unmitigated project performance resulted as follows:

- Mean value of total unescalated cost - $4.238 million (February 2016$), $1.170 million more than the total unescalated base cost
- Mean value of total escalated cost - $4.668 million (YOE), $1.363 million more than total escalated base cost
- Mean value of project construction completion date – 2/27/2020, 12.24 months longer than the base construction completion date of 2/20/2019

The unmitigated top risks are presented, in rank order of mean severity, in Table 4.2 (Step 5 of the R09 Risk Template). The unmitigated risks and the three identified unmitigated opportunities are presented in the form of a “tornado diagram” in Figure 4.1 (Step 7 of the R09 Risk Template). The mean severity and ranking of all risks are presented in the completed R09 Risk Template (**Attachment B**).

Table 4.2. Unmitigated Risk Rankings

Risk Label	Risk Description	Risk Type	Mean Severity (YOE $M)	Percent of Total Severity	Risk Ranking based on Mean Severity	Select Risk for Mitigation
PD-2	Enivro assessment turns into EIS requirement	Threat	0.34	17.55%	1	Yes
EP-3	USACOE Permit longer than anticipated	Threat	0.27	14.07%	2	Yes
CR-20	Access to additional funding in case of overruns	Threat	0.20	10.20%	3	Yes
PD-7	Public opposition to disturbance of wetlands	Threat	0.15	7.90%	4	Yes
CR-11	Moving of high voltage power lines takes longer than expected	Threat	0.15	7.90%	5	Yes
PD-6	Rejection of HH study by DNR	Threat	0.08	4.37%	6	Yes
CR-15	MOT during adjustment of grade	Threat	0.08	3.97%	7	Yes
PD-9	Litigous culture of contractors	Threat	0.06	3.38%	8	Yes
CR-6	Extreme weather events/hurricane	Threat	0.06	3.29%	9	Yes
CR-16	Additional subgrade preperation for piles/pavement	Threat	0.06	3.29%	10	Yes
CR-22	Rock slope instability	Threat	0.06	3.29%	11	No
PD-5	Existing rails found to be historical	Threat	0.06	3.27%	12	Yes
F3-1	Lead paint removal is non-participating	Threat	0.06	2.95%	13	Yes
CR-4	Enivro condition due to pile driving (vibrations vs soil)	Threat	0.04	2.17%	14	No
PD-4	Public request for additional vertical clearance	Threat	0.04	2.00%	15	No
CR-1	Rupture of existing diesel line during consturction	Threat	0.04	1.99%	16	No
CR-21	Violation of permit conditions	Threat	0.04	1.99%	17	Yes
CR-9	Limited construction staging area for contractor	Threat	0.02	1.04%	18	No
CR-7	Construction noise effect on wildlife	Threat	0.02	0.90%	19	No
PD-8	Municipality requests area of existing bridge turned to recreational area	Threat	0.02	0.89%	20	No
CR-5	Damage to marina wall during destruction of abutment	Threat	0.02	0.89%	21	No
CR-18	Fisherman under new bridge during construction	Threat	0.01	0.48%	22	No
CR-8	Limited construction timeframe (daily basis), MOT	Threat	0.01	0.47%	23	No
CR-10	Moving of overhead lines takes longer than expected	Threat	0.01	0.47%	24	No
CR-13	Only one contractor to build box beams	Threat	0.01	0.46%	25	No
CR-3	Existing bridge require premature closure/restrictions	Threat	0.01	0.43%	26	No
EP-1	More wetland mitigation required than planned	Threat	0.00	0.18%	27	No
CR-14	Relocation of underground utilities affects MOT	Threat	0.00	0.12%	28	No
PD-3	Public opposition to horizontal alignment	Threat	0.00	0.05%	29	No
PD-10	Components of existing bridge deemed historical	Threat	0.00	0.04%	30	No
EP-2	Finding place to replace affected trees, may require additional ROW	Threat	0.00	0.02%	31	No
PR-1	Aggressive bidding brings costs down	Opportunity	-0.12	98.28%	1	Yes
CR-2	Innovation in construction techniques brings costs down	Opportunity	0.00	1.37%	2	No
CR-19	Competition from another pre-cast manufacturer	Opportunity	0.00	0.34%	3	No
PD-1	Relocation of food truck vendors	No Impact	0.00	0.00%		No
CR-12	Restrictions from biological assessment limit construction times	No Impact	0.00	0.00%		No
CR-17	Transportation of materials	No Impact	0.00	0.00%		No

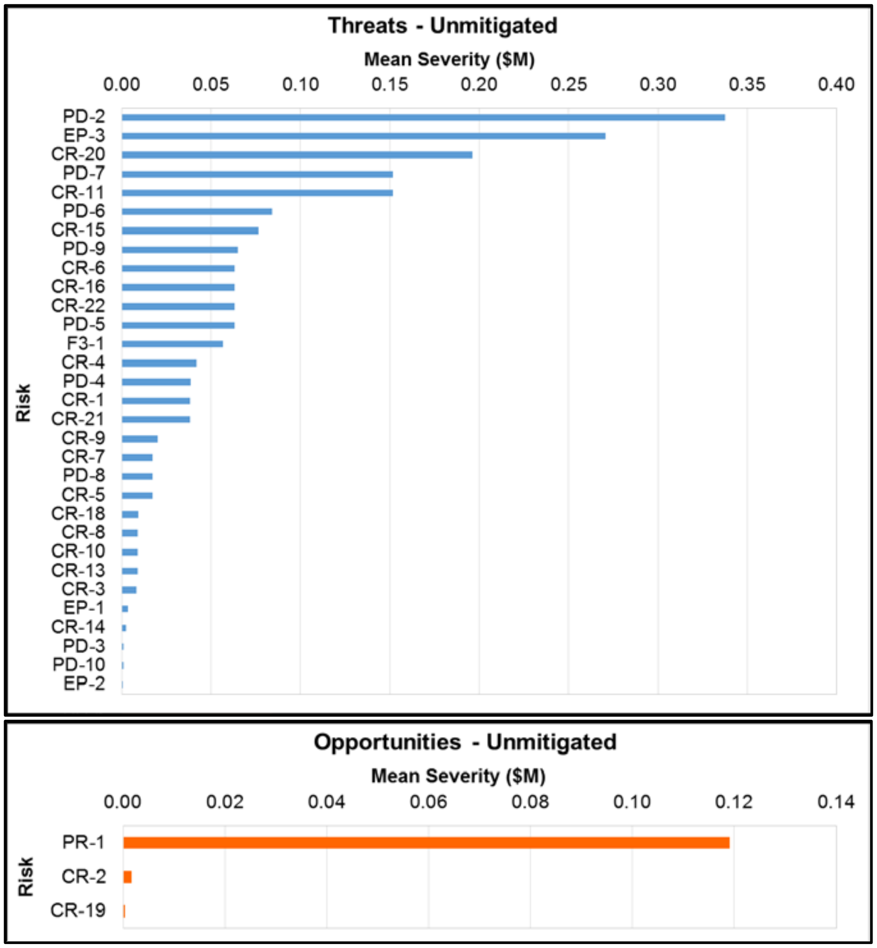


Figure 4.1. Tornado Chart for Unmitigated Risk Ranking

5 RISK MITIGATION PLANNING

In a facilitated environment, the project team and project-independent subject matter experts:

- First identified possible ways to reduce the significant risks (and exploit the significant opportunities), and
- Then, assessed (by consensus) the various factors that define the cost-effectiveness of each action in reducing risks (or exploiting opportunities) and thereby improving project performance. These factors include:
    - Mean changes in the base factors (cost and schedule, by activity) associated with implementing the action (regardless of effectiveness), e.g., action A will cost about $1.0M to implement, and
    - Mean changes in the risk factors (cost and schedule impacts, by activity, and probability of occurrence) as a result of that action, e.g., action A will reduce the probability of risk R occurring by about 1/2.

These actions, and their assessed factors, were documented in the **"Risk Mitigation Strategies Register" (Step 8 of the R09 Risk Template**). Also, **Step 9 of the R09 Risk Template illustrates the Mitigation Strategies Register** for the selected risk mitigation actions.

The cost-effectiveness of each action was then determined (in terms of its net change in combined project performance) by appropriately combining the above information. Cost-effective actions were then selected and plans developed for them, including responsibility and schedule for completion (Step of R09 Risk Template).

The risk reduction plan is presented in the following tables:

- Table 5.1 (Step 8 of the R09 Risk Template) lists possible risk mitigation actions for the highest ranked risks and the calculated (using the R09 Risk Template) cost-effectiveness of each action. The cost effectiveness is presented in terms of the mitigated severity and benefit/cost ratio.
- Table 5.2 (Step 9 of the R09 Risk Template) shows the selected cost-effective set of actions and plans for implementing them (Mitigation Strategies Register).
- Table 5.3 (Step 10 of the R09 Risk Template) shows the calculated Mitigated Risk Register (in terms of mitigated mean severity) for the selected set of actions.

Table 5.1. Detailed Identification of Risk Mitigation Actions & Cost-Effectiveness Assessment

Risk Mitigation Label	Risk Mitigation Actions	Implementation Needs of Risk Mitigation Actions						Consequences of Risk Mitigation Actions								Effectiveness of Risk Mitigation Actions		
		Cost		Schedule		Disruption		New Probability		Percentage Mitigated, if implemented								
		Mean Cost (CY $M)	Affected Phase	Mean Duration (months)	Affected Phase	Mean Disruption (M-Hr)	Affected Phase	Adjectival (VL, L, M, H, VH)	Numerical	Cost (%)	Mean Cost (CY $M)	Duration (%)	Mean Duration (months)	Disruption (%)	Mean Disruption (M-Hr)	Mitigated Severity (%)	Benefit/Cost Ratio	Action Selected
PD-2	Enivro assessment turns into EIS requirement																	
PD-2_1	Do Nothing								0.30	0.00	0.01759	0.00	18	0.00	0			No
PD-2_2	Enhance EA	0.01	Prelim Design/Environmental Process	2.00	Prelim Design/Environmental Process				0.15	10.00	0.00	2.70	2.63		0.00	51.71	1.32	No
PD-2_3	Early Involvement with Stakeholders, Leaders & Permitting Agencies	0.00	Prelim Design/Environmental Process	0.00	Prelim Design/Environmental Process				0.15		0.00	2.70	2.63		0.00	51.64	No Cost	No
PD-2_4	Minimize Affected Area of Project Footprint during Construction	0.00	Construction	0.00	Construction				0.50	100.00	0.00	100.00	0.00		0.00	100.00	No Cost	Yes
PD-2_5																		No
EP-3	USACOE Permit longer than anticipated																	
EP-3_1	Do Nothing								0.55	0.00	0	0.00	8	0.00	0			No
EP-3_2	Early involvement of USACOE	0.00	Prelim Design/Environmental Process	0.00	Prelim Design/Environmental Process				0.25	0.00	0.00	75.00	0.50		0.00	88.74	No Cost	Yes
EP-3_3																		No
EP-3_4																		No
EP-3_5																		No
CR-20	Access to additional funding in case of overru																	
CR-20_1	Do Nothing								0.55	0.00	0.07036	0.00	2.5	0.00	0			No
CR-20_2	Pass along issues as early as possible	0.00	Construction	0.00	Construction				0.50		0.04	50.00	0.63		0.00	45.13	No Cost	Yes
CR-20_3																		No
CR-20_4																		No
CR-20_5																		No
PD-7	Public opposition to disturbance of wetlands																	
PD-7_1	Do Nothing								0.30	0.00	0.22867	0.00	2.5	0.00	0			No
PD-7_2	Early community involvement	0.00	Prelim Design/Environmental Process	0.00	Prelim Design/Environmental Process				0.15		0.03		0.38		0.00	50.05	No Cost	Yes
PD-7_3																		No
PD-7_4																		No
PD-7_5																		No
CR-11	Moving of high voltage power lines takes long																	
CR-11_1	Do Nothing								0.30	0.00	0.22867	0.00	2.5	0.00	0			No
CR-11_2	Negotiate MOU w/power authority	0.00	Prelim Design/Environmental Process	0.00	Prelim Design/Environmental Process				0.20	100.00	0.00	100.00	0.00		0.00	100.00	No Cost	Yes
CR-11_3																		No
CR-11_4																		No
CR-11_5																		No
PD-6	Rejection of HH study by DNR																	
PD-6_1	Do Nothing								0.55	0.00	0	0.00	2.5	0.00	0			No
PD-6_2	Early involvement of DNR	0.00	Prelim Design/Environmental Process	0.00	Prelim Design/Environmental Process				0.25		0.00	50.00	0.31		0.00	77.33	No Cost	Yes
PD-6_3																		No
PD-6_4																		No
PD-6_5																		No
CR-15	MOT during adjustment of grade																	
CR-15_1	Do Nothing								0.55	0.00	0.07036	0.00	0.625	0.00	0			No
CR-15_2	Emphasize phases of MOT	0.00	Final Design	0.00	Final Design				0.05	100.00	0.00	85.00	0.00		0.00	99.34	No Cost	Yes
CR-15_3																		No
CR-15_4																		No
CR-15_5																		No
PR-1	Aggressive bidding brings costs down																	
PR-1_1	Do Nothing								0.55	0.00	-0.22867	0.00	0	0.00	0			No
PR-1_2	Special pre-bid meeting for contractors	0.00	Procurement	0.00	Procurement				0.65		-0.15		0.00		0.00	-18.18	No Cost	Yes
PR-1_3																		No
PR-1_4																		No
PR-1_5																		No
PD-9	Litigous culture of contractors																	
PD-9_1	Do Nothing								0.30	0.00	0.22867	0.00	0.625	0.00	0			Yes
PD-9_2																		No
PD-9_3																		No
PD-9_4																		No
PD-9_5																		No
CR-16	Additional subgrade preperation for piles/pavement																	
CR-16_1	Do Nothing								0.13	0.00	0.22867	0.00	2.5	0.00	0			No
CR-16_2	More detailed subgrade soil investigation	0.01	Final Design	0.00	Final Design				0.00	100.00	0.00	100.00	0.00		0.00	100.00	6.48	Yes
CR-16_3																		No
CR-16_4																		No
CR-16_5																		No

For several risks, only a single mitigation action was discussed. For example, for risk EP-3 (USACOE permitting time longer than expected), the only mitigation action discussed was to ensure the U.S. Army Corps of Engineers was involved in the project from an early stage. Implementing this action had no effect on the project in terms of cost or schedule as it was a step that was already planned. However, by involving the USACOE from an early standpoint, the probability of this risk occurring was reduced from 55% to 25%. Additionally, if the permitting time still took longer than originally anticipated, the likely duration impact to the project was reduced by 75%. (In this case there was no change to the cost impact of the project if the risk occurred as a result of implementing this mitigation action.) Combining the new probability and the reduced duration impact, the mean severity of risk EP-3 was reduced from $0.27M (YOE) to $0.03M (YOE), resulting in a mitigated severity of 88.7%.

For risk PD-2 (Original Environmental Assessment (EA) turns into Environmental Impact Study (EIS)), three mitigation actions were discussed, including enhancing the EA from the outset, early involvement of key stakeholders and permitting agencies, and minimizing the affected project footprint during construction. Each of these mitigation alternatives had varying implementation requirements for cost and schedule, and each had varying degrees of success in terms of mitigating risk cost and schedule. However, by minimizing the area affected by the construction, 100% of the cost and schedule impacts resulting from the risk were mitigated. This was the option selected by the participants for risk mitigation of PD-2.

The mitigated risks and the selected mitigation strategies for each risk are shown below in Table 5.2. Note that for risk PD-9, it was determined that no mitigation action was feasible for this project.

Table 5.2. Mitigation Strategies Register

Risk Label	Risk Description	Risk Mitigation Label	Risk Mitigation Action Description	Implementation Effort					Mitigated Risk Effort					Effectiveness of Mitigation Actions		Responsibility	Schedule /Milestone	Comments
				Mean Cost Change (YOE $M)	Mean Duration Change (YOE $M)	Mean Disruption Change (YOE $M)	Mean Change to Crit. Path (YOE $M)	Mean Severity (YOE $M)	Mean Cost Change (YOE $M)	Mean Duration Change (YOE $M)	Mean Disruption Change (YOE $M)	Mean Change to Crit. Path (YOE $M)	Mean Severity (YOE $M)	Mitigated Severity %	Benefit/Cost Ratio			
PD-2	Enivro assessment turns into EIS requirement	PD-2_4	Minimize Affected Area of Project Footprint during Construction	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	No Cost	R. Morales	Prelim/Final Design	Ensure Mgmnt informed of action
EP-3	USACOE Permit longer than anticipated	EP-3_2	Early involvement of USACOE	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.50	0.03	88.74	No Cost			
CR-20	Access to additional funding in case of overruns	CR-20_2	Pass along issues as early as possible	0.00	0.00	0.00	0.00	0.00	0.04	0.63	0.00	0.63	0.11	45.13	No Cost			
PD-7	Public opposition to disturbance of wetlands	PD-7_2	Early community involvement	0.00	0.00	0.00	0.00	0.00	0.03	0.38	0.00	0.38	0.08	50.05	No Cost			
CR-11	Moving of high voltage power lines takes longer than expected	CR-11_2	Negotiate MOU w/power authority	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	No Cost			
PD-6	Rejection of HH study by DNR	PD-6_2	Early involvement of DNR	0.00	0.00	0.00	0.00	0.00	0.00	0.31	0.00	0.31	0.02	77.33	No Cost			
CR-15	MOT during adjustment of grade	CR-15_2	Emphasize phases of MOT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	99.34	No Cost			
PR-1	Aggressive bidding brings costs down	PR-1_2	Special pre-bid meeting for contractors	0.00	0.00	0.00	0.00	0.00	-0.15	0.00	0.00	0.00	-0.16	-18.18	No Cost			
PD-9	Litigous culture of contractors	PD-9_1	Do Nothing															
CR-16	Additional subgrade preperation for piles/pavement	CR-16_2	More detailed subgrade soil investigation	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	100.00	6.48			

Even after mitigation strategies are enacted to mitigate risk, residual risk still remains on the project. Generally speaking, the severity of risk remaining to the project after mitigation is substantially less (for threats) than the unmitigated risk. In this case, the total mean severity was reduced from $1.80 million (Cell N38 in Step 6 of template) to $0.67 million (Cell N39 in Step 11 of template). (For opportunities, the remaining mean severity after implementing the mitigations increases.)

For the PR681/Bridge 702 project, the greatest residual risks were CR-20, PD-7, and PD-9. The mean severity for the greatest risk following mitigation, CR-20, was $0.11 million. Comparatively, the greatest unmitigated risk (from Step 5 of Template) was PD-2 with a mean severity of approximately $0.34 million (YOE). The top three risks after mitigation account for $0.26 million of mean severity, or approximately 31% of the total (from Step 10 of Template). Fifty-three percent of the total mitigated mean severity is from the top six risks, as shown in Table 5.3 below.

Table 5.3. Mitigated Risk Register (Mitigated Risk Assessment)

Risk Label	Risk Description	Risk Type	Mean Cost Impact (CY $M)	Mean Duration Impact (months)	Mean Disruption Impact (M-Hr)	Mean Change to Critical Path Schedule	Mean Severity (YOE $M)	Percent of Total Mean Severity	Risk Ranking based on Mean Severity	Retire Risk ?
CR-20	Access to additional funding in case of overruns	Threat	0.04	0.63	0.00	0.63	0.11	0.13	1	No
PD-7	Public opposition to disturbance of wetlands	Threat	0.03	0.38	0.00	0.38	0.08	0.10	2	No
PD-9	Litigous culture of contractors	Threat	0.06	0.19	0.00	0.00	0.06	0.08	3	No
CR-6	Extreme weather events/hurricane	Threat	0.02	0.31	0.00	0.31	0.06	0.08	4	No
CR-22	Rock slope instability	Threat	0.02	0.31	0.00	0.31	0.06	0.08	5	No
PD-5	Existing rails found to be historical	Threat	0.00	1.00	0.00	1.00	0.06	0.08	6	No
F3-1	Lead paint removal is non-participating	Threat	0.05	0.00	0.00	0.00	0.06	0.07	7	No
CR-4	Enivro condition due to pile driving (vibrations vs soil)	Threat	0.02	0.19	0.00	0.19	0.04	0.05	8	No
PD-4	Public request for additional vertical clearance	Threat	0.03	0.07	0.00	0.07	0.04	0.05	9	No
CR-1	Rupture of existing diesel line during consturction	Threat	0.00	0.31	0.00	0.31	0.04	0.05	10	No
CR-21	Violation of permit conditions	Threat	0.00	0.31	0.00	0.31	0.04	0.05	11	No
EP-3	USACOE Permit longer than anticipated	Threat	0.00	0.50	0.00	0.50	0.03	0.04	12	No
CR-9	Limited construction staging area for contractor	Threat	0.02	0.00	0.00	0.00	0.02	0.02	13	No
PD-6	Rejection of HH study by DNR	Threat	0.00	0.31	0.00	0.31	0.02	0.02	14	No
CR-7	Construction noise effect on wildlife	Threat	0.01	0.08	0.00	0.08	0.02	0.02	15	No
PD-8	Municipality requests area of existing bridge turned to recreational area	Threat	0.01	0.07	0.00	0.07	0.02	0.02	16	No
CR-5	Damage to marina wall during destruction of abutment	Threat	0.01	0.07	0.00	0.07	0.02	0.02	17	No
CR-18	Fisherman under new bridge during construction	Threat	0.01	0.00	0.00	0.00	0.01	0.01	18	No
CR-8	Limited construction timeframe (daily basis), MOT	Threat	0.00	0.08	0.00	0.08	0.01	0.01	19	No
CR-10	Moving of overhead lines takes longer than expected	Threat	0.00	0.08	0.00	0.08	0.01	0.01	20	No
CR-13	Only one contractor to build box beams	Threat	0.00	0.06	0.00	0.06	0.01	0.01	21	No
CR-3	Existing bridge require premature closure/restrictions	Threat	0.01	0.00	0.00	0.00	0.01	0.01	22	No
EP-1	More wetland mitigation required than planned	Threat	0.00	0.02	0.00	0.02	0.00	0.00	23	No
CR-14	Relocation of underground utilities affects MOT	Threat	0.00	0.02	0.00	0.02	0.00	0.00	24	No
PD-3	Public opposition to horizontal alignment	Threat	0.00	0.02	0.00	0.02	0.00	0.00	25	No
PD-10	Components of existing bridge deemed historical	Threat	0.00	0.00	0.00	0.00	0.00	0.00	26	No
CR-15	MOT during adjustment of grade	Threat	0.00	0.00	0.00	0.00	0.00	0.00	27	No
EP-2	Finding place to replace affected trees, may require additional ROW	Threat	0.00	0.00	0.00	0.00	0.00	0.00	28	No
PR-1	Aggressive bidding brings costs down	Opportunity	-0.15	0.00	0.00	0.00	-0.16	0.99	1	No
CR-2	Innovation in construction techniques brings costs down	Opportunity	0.00	0.00	0.00	0.00	0.00	0.01	2	No
CR-19	Competition from another pre-cast manufacturer	Opportunity	0.00	0.00	0.00	0.00	0.00	0.00	3	No
PD-2	Enivro assessment turns into EIS requirement	No Impact	0.00	0.00	0.00	0.00	0.00	0.00		No
CR-11	Moving of high voltage power lines takes longer than expected	No Impact	0.00	0.00	0.00	0.00	0.00	0.00		No
CR-16	Additional subgrade preperation for piles/pavement	No Impact	0.00	0.00	0.00	0.00	0.00	0.00		No
PD-1	Relocation of food truck vendors	No Impact	0.00	0.11	0.00	0.00	0.00	0.00		No
CR-12	Restrictions from biological assessment limit construction times	No Impact	0.00	0.00	0.00	0.00	0.00	0.00		No
CR-17	Transportation of materials	No Impact	0.00	0.00	0.00	0.00	0.00	0.00		No

6 RISK ANALYSIS RESULTS – AFTER MITIGATION

The base performance factors, mitigation implementation, and risk factors after mitigation were appropriately combined (using the R09 Risk Template) to determine the following:

- Approximate mean values of base plus risk project performance considering mitigation, including:
    - Project schedule (duration, start and end dates, and float by activity, and key milestone dates)
    - Project cost (unescalated and escalated, by activity and collectively
    - Project combined performance (combination of escalated project cost and schedule through construction).
- Mean "severity" of each risk, in terms of its contribution to mean combined project performance considering mitigation, and ranking of risks on that basis. Severity is the combined effect of the probability of occurrence and the impacts to cost, schedule, and disruption (when applicable).

These results are presented in following tables and figure:

- Table 6.1 (Section 11 of the R09 Risk Template) illustrates the mitigated base plus risk project performance. It should be noted that these mean values of project performance are very approximate (for various reasons) and should be used with caution. More accurate results would require a full probabilistic risk analysis. After applying the mitigation strategies to the top eight (8) threats and top one opportunity, the project performance resulted in:
    - Mean value of total unescalated cost - $3.529 million (February 2016$), $709,000 less than unmitigated unescalated cost.
    - Mean value of total escalated cost - $3.817 million (YOE), $851,000 less than unmitigated escalated cost.
    - Mean value of project construction completion date – 5/28/2019, 9.0 months less than unmitigated construction completion date.

  Note that the top nine (9) threats and the highest severity opportunity (PR-1) were originally selected for mitigation. However, it was determined that for one of the threats, PD-9, no mitigation action was prudent, so no further mitigation options were proposed or discussed.

- Figure 6.1 illustrates (Step 12 of the R09 Risk Template) in form of a tornado diagram the mitigated risks and three opportunities in rank order of mean severity. The mean severity and ranking of all risks are presented in the completed R09 template **(Attachment B)**.

Table 6.1. Mitigated Base plus Risk Project Performance

Mitigated Project Cost, Duration, and Disruption Performance

Project Phase	Base + Implementation			Residual Risk			Total (Base + Implementation + Residual Risk)			
	Cost (CY $M)	Duration (months)	Disruption (M-hrs)	Cost (CY $M)	Duration (months)	Disruption (M-hrs)	Cost (CY $M)	Duration (months)	Disruption (M-hrs)	Cost (YOE $M)
Planning	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Scoping	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Prelim Design/Environmental Process	0.24	13.60	0.00	0.04	1.45	0.00	0.27	15.05	0.00	0.28
Environmental Permits	0.28	0.00	0.00	0.00	0.00	0.00	0.28	0.00	0.00	0.29
ROW/Util/RR	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.11	0.00	0.00
Final Design	0.01	5.00	0.00	0.00	0.00	0.00	0.01	5.00	0.00	0.01
Procurement	0.00	6.00	0.00	0.07	0.00	0.00	0.07	6.00	0.00	0.08
Construction	2.55	18.00	0.00	0.34	1.77	0.00	2.89	19.77	0.00	3.16
Operations & Maintenance	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Replacement	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Total (through Construction	**3.08**		**0.00**	**0.45**		**0.00**	**3.53**		**0.00**	**3.82**
Total (through Replacement	**3.08**		**0.00**	**0.45**		**0.00**	**3.53**		**0.00**	**3.82**

Project Schedule Performance (Unmitigated vs. Mitigated)

Project Phase	Unmitigated Project Schedule Performance (from step 6)						Mitigated Project Schedule Performance						Mean
	Duration (Months/ Date)	Early Start	Early Finish	Late Start	Late Finish	Float (months)	Duration (Months/ Date)	Early Start	Early Finish	Late Start	Late Finish	Float (months)	Severity YOE($M)
Planning	0.00	8/5/2015	8/5/2015	8/5/2015	8/5/2015	0.00	0.00	8/5/2015	8/5/2015	8/5/2015	8/5/2015	0.00	0.00
Scoping	0.00	8/5/2015	8/5/2015	8/5/2015	8/5/2015	0.00	0.00	8/5/2015	8/5/2015	8/5/2015	8/5/2015	0.00	0.00
Design Funding Date	8/5/2015		8/5/2015		8/5/2015	0.00	8/5/2015		8/5/2015		8/5/2015	0.00	0.00
Prelim Design/Environmental Process	22.43	8/5/2015	6/16/2017	8/5/2015	6/16/2017	0.00	15.05	8/5/2015	11/4/2016	8/5/2015	11/4/2016	0.00	0.29
Environmental Permits	0.00	6/16/2017	6/16/2017	11/15/2017	########	5.00	0.00	11/4/2016	11/4/2016	4/5/2017	4/5/2017	5.00	0.03
ROW/Util/RR Funding Date	8/5/2015		8/5/2015		9/16/2017	25.43	8/5/2015		8/5/2015		2/3/2017	18.05	0.00
ROW/Util/RR	0.11	6/16/2017	6/20/2017	11/12/2017	########	4.89	0.11	11/4/2016	11/7/2016	4/2/2017	4/5/2017	4.89	0.00
Final Design	5.00	6/16/2017	11/15/2017	6/16/2017	########	0.00	5.00	11/4/2016	4/5/2017	11/4/2016	4/5/2017	0.00	0.06
Construction Funding Date	8/5/2015		8/5/2015		########	27.43	8/5/2015		8/5/2015		4/5/2017	20.05	-0.16
Procurement	6.00	11/15/2017	5/17/2018	11/15/2017	5/17/2018	0.00	6.00	4/5/2017	10/4/2017	4/5/2017	10/4/2017	0.00	0.00
Construction	21.41	5/17/2018	2/27/2020	5/17/2018	2/27/2020	0.00	19.77	10/4/2017	5/28/2019	10/4/2017	5/28/2019	0.00	0.45
Operations & Maintenance	0.00	2/27/2020	2/27/2020	2/27/2020	2/27/2020		0.00	5/28/2019	5/28/2019	5/28/2019	5/28/2019		
Replacement	0.00	2/27/2020	2/27/2020	2/27/2020	2/27/2020		0.00	5/28/2019	5/28/2019	5/28/2019	5/28/2019		
Project Start Date	**8/5/2015**						**8/5/2015**					**Total**	0.67
Construction Finish Date	**2/27/2020**						**5/28/2019**						
Project Duration (months)	**54.84**						**45.82**						

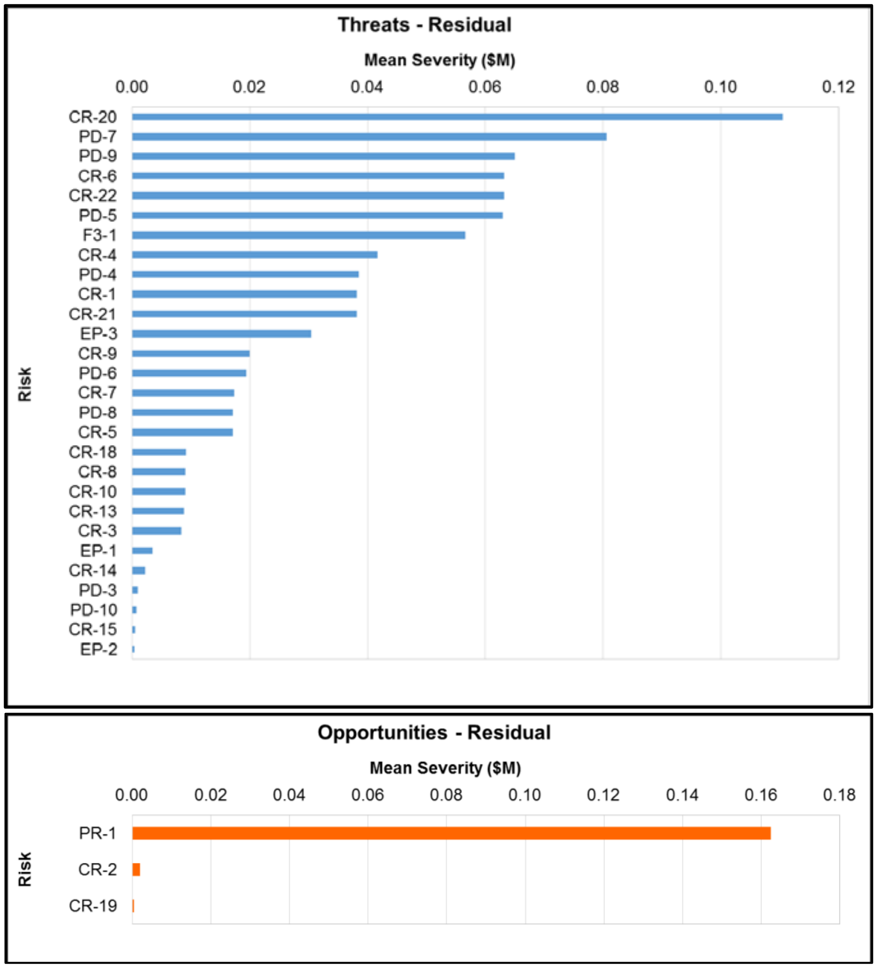


Figure 6.1. Tornado Chart for Mitigated Risk Ranking

7 CONTINGENCY MANAGEMENT

Contingency funds and float are needed on top of the base cost and schedule, respectively, to adequately cover (with appropriate confidence) the risks that actually occur during a project. Cleary, such contingencies generally cannot be based on worst-possible-case assumptions, because that would usually be unaffordable (e.g., commit too much money and time, possibly starving other projects). Instead, a “reasonable” level of confidence is needed, appropriately reflecting the “pain” of exceeding available contingency, i.e., the more pain involved, the higher the confidence level should be. In the past, cost contingencies have often been based strictly on judgment (with industry guidance), as a percentage of the project cost; however, such empirically-derived contingencies have often proven to be inadequate, although occasionally they prove to be excessive. Often, there is no explicit schedule contingency, resulting in missed milestones.

The amount of cost and schedule contingency needed for each phase would ideally be developed by full probabilistic risk analysis, in which the uncertainty in project cost and schedule would be determined and the values associated with a specified confidence level (which would be a PRHTA policy decision) could be identified. In the absence of such analyses, judgment must be used. PRHTA may wish to incorporate such contingency subsequent to the simplified risk management workshop.

8 RISK MANAGEMENT PLAN IMPLEMENTATION

In order to successfully implement this Risk Management Plan, and thereby realize improved project performance, the following is required:

- PRHTA commitment to the Risk Management Plan.
- Designated Project Risk Manager, with adequate authority and resources to carry out this Risk Management Plan to:
    - monitor and periodically update the Risk Register, i.e., regarding changes in risk factors and in associated results
    - monitor and periodically update this Risk Management Plan, i.e., regarding:
        - status/progress and results of selected risk reduction actions, and possible redirection,
        - adequacy of remaining contingency, and recommendations regarding contingency management and implementation of recovery plans
        - status/adequacy of recovery plans

  Monitoring is typically done via short interviews with select project staff (e.g., as part of weekly or monthly project progress meetings), whereas updating requires additional effort (e.g., short workshop).

- Adequate information systems to support implementation of his Risk Management Plan, e.g., regarding gathering, interpreting and distributing relevant information

A recovery plans is a plan developed by the project team detailing how the project will be financially supported against additional expenses if the contingency is exhausted. The contingency is computed assuming the risk mitigation plan outlined in Section 5 (Step 9 of the R09 Risk Template) is fully implemented.

Step 9 of the R09 Risk Template also provides an area for critical documentation of strategies and responsibilities. Here the project team can take the important step of assigning responsibility to an individual or group to facilitate and manage the selected risk mitigation strategy. For example, the PRHTA project team assigned the responsibility for implementation of strategy PD-2_4 to the project manager. In this case, he is responsible for ensuring management is informed of actions to reduce the project footprint prior to completion of the Preliminary Engineering and Design phase.

It is of utmost importance that each mitigation strategy is assigned to a responsible individual or group who will champion the effort to see the strategy through to completion. Without a champion, many mitigation strategies will falter or be overlooked completely, exposing the project to greater risk of cost overrun or delay.

9 CONCLUSIONS

A suitable Risk Management Plan has been defensibly developed for the Puerto Rico Highway and Transportation Authority's Bridge 702/PR-681reconstruction project to improve and control project performance (i.e., schedule, cost). This plan consists of two main elements:

- A program of actions intended to proactively and cost-effectively reduce the significant project risks (and exploit key opportunities), where the risks were meaningfully evaluated in terms of their "severity" with respect to the project's combined performance (combination of schedule and cost).
- Establishment and management of cost and schedule contingency throughout project development to confidently cover the remaining risks. PRHTA will need to develop and apply its policy on contingency management to establish an appropriate contingency, which might (in part) be informed by the mean-value results from this R09 simplified risk management process.

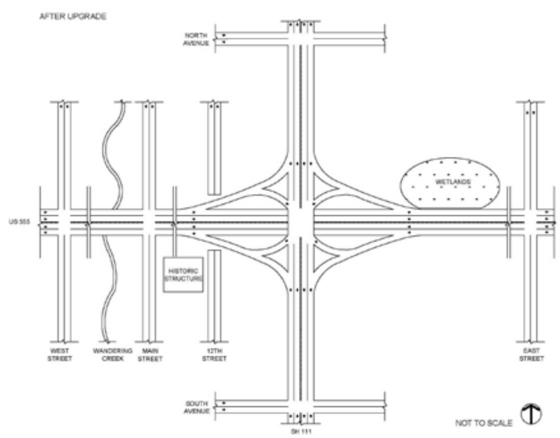
In addition, the requirements for successfully implementing this Risk Management Plan have been identified, e.g., organizational structure and resources.

FHWA and AASHTO hope that the PRHTA participants developed an understanding of the R09 simplified risk management process and can see its value on other PRHTA projects, particularly since PRHTA staff should be able to implement this process internally.

FHWA and AASHTO suggest early implementation of the R09 risk management process during project design and before the environmental process (e.g., NEPA) is finalized. It is also suggested that the R09 risk management process be coordinated with the value engineering program. These processes would strongly complement each other from project identification through alternatives analysis.

Risk Management Plan

for US 555 / SH 111 Project



for
QDOT

15 Feb 2010

Table of Contents

List of Attachments

List of Figures

EXECUTIVE SUMMARY

QDOT is planning to reconstruct and expand segments of two existing (intersecting) highways, US 555 and SH 111, through a rapidly-developing suburban area. QDOT wants to minimize cost, schedule and disruption through construction, and maximize longevity after construction. To help achieve these objectives, QDOT will use design/build project delivery, as well as encourage accelerated construction methods.

In order to further improve and control ultimate project performance where innovative methods are being used, QDOT conducted formal risk management, as described in the "Guide for Managing Risks for Rapid Renewal Projects" (TRB, 2010). Such risk management involves appropriately anticipating and planning for potential problems (risks), as well as opportunities (negative risks), and is documented in this project *Risk Management Plan*.

This *Risk Management Plan* consists of the following elements:

- Description of the project
- Identification of current risks, and assessment of their factors
- Analysis of project performance, and ranking of risks in terms of their contribution to this project performance
- Identification of ways to proactively reduce significant individual risks, and evaluation of their cost-effectiveness
- Selection, planning and implementation of cost-effective ways to proactively reduce significant individual risks
- Establishment and management of cost and schedule contingency to cover (to a high level of confidence) remaining risks throughout the project
- Establishment and management of "recovery" plans (in case contingencies are insufficient)
- Establishment of organizational structure and resources to successfully implement the *Risk Management Plan*.

<this page left intentionally blank>

1.0 INTRODUCTION

1.1 Purpose and Objectives

The primary purpose of this *Risk Management Plan* is to provide appropriate plans (and adequate justification of those plans) for improving and controlling “performance” (i.e., cost, schedule, disruption, and longevity) of the project, by focusing on controlling project risks (both individually and collectively).

Quantification of the uncertainty in project performance, e.g., to help establish budgets, milestones, and contingencies at QDOT-specified confidence levels, is not currently part of the scope of this *Risk Management Plan*, but could be added later (e.g., by addendum).

1.2 Approach

The approach taken in developing this plan is adopted from “Guide for Managing Risks for Rapid Renewal Projects” (TRB, 2010). This approach consists of the following steps, as documented in this plan:

- Project Description (Section 2) - Develop an adequate understanding of the project (as documented in a specific format) and its likely “base” (without “risk”) performance (i.e., regarding schedule, cost, and disruption through construction, and post-construction longevity). As part of this, develop a simple but adequate cost- and disruption-loaded project schedule.
- Pre-Mitigation Risk Identification and Assessment (Section 3) – Develop a comprehensive and non-over-lapping set of project performance risks, which are possible events that, if they occur, can change project performance, and categorize the list by when during project development the risks would occur. For each of the risks, adequately assess the factors defining those risks, including the likely impacts (e.g., change in unescalated cost to a particular project activity) if the risk occurs, and the likelihood of the event (as defined by those impacts) occurring.
- Pre-Mitigation Risk Analysis (Section 4) – Determine likely project performance, including the risks, and especially the relative significance of the various risks in affecting that performance (“sensitivity”), before any additional mitigation.
- Risk Reduction Planning (Section 5) – Identify possible actions to proactively reduce individual risks, focusing on the most significant risks, and evaluate their cost-effectiveness. Select and adequately plan (i.e., assign responsibility and resources) the set of cost-effective actions.
- Post-Mitigation Risk Analysis (Section 6) – Determine likely project performance, including the risks, and especially the relative significance of the various risks in affecting that performance (“sensitivity”), considering additional mitigation.
- Contingency Management (Section 7) – Establish contingency requirements (cost and schedule allowances) for the various phases of project development, based on likely project performance considering collectively the residual risks for each phase if the risk reduction plans are adopted and implemented. Also establish adequate procedures for how those contingencies will be controlled.
- Recovery Planning (Section 8) – Establish plans for what to do if contingencies turn out to be insufficient (e.g., defer scope through contract options) during various phases of project development. Also establish adequate procedures for how those plans will be triggered.

- *Risk Management Plan* Implementation (Section 9) – Identify the organizational structure and resources required to successfully implement this *Risk Management Plan*.

Each of the above steps is briefly discussed in the following sections, with details presented in attachments (including the filled-in template in Attachment I).

2.0 PROJECT DESCRIPTION

2.1 Project Summary

QDOT is planning to reconstruct and expand segments of two existing (intersecting) highways, US 555 and SH 111, through a rapidly-developing suburban area. The existing highways are nearly 40 years old, have increasingly inadequate capacity, and are expensive to maintain. These facilities are the only viable east-west (US 555) and north-south (SH 111) routes for commercial traffic for several miles in either direction. Therefore, it is imperative that the necessary improvements be made quickly and with minimal disruption. QDOT would also like to minimize construction costs and future repair cycles and maintenance requirements, as well as eventual replacement issues.

To help achieve these objectives, QDOT plans to encourage contractor innovation through the use of performance-based specifications and incentives, and to procure with an innovative project delivery method (i.e., design-build or D/B). It is expected that accelerated bridge construction techniques, minimally disruptive MOT, and innovative pavement design, among other rapid renewal elements, will be considered for this project.

A detailed project description, including major assumptions and conditions, is presented in Attachment A.

2.2 Base Project Schedule

As presented in Attachment B (Table B-3), for the assumptions outlined above, the “base” project schedule (without risk) was developed from QDOT’s latest project schedule, using a standard simplified project flowchart for D/B with base durations, lags, and milestones for the various activities. QDOT’s project schedule was first reviewed and “de-biased”, removing any float. In general terms of overall pre-construction and construction schedules, the base project schedule (before risk and opportunity) is 18 months from present time to reach contractor NTP, then 17 months for D/B design and construction, with a target completion date of 01 November 2012. The project team is also assuming a 50-year time to replacement (which takes two years).

2.3 Base Project Cost

As presented in Attachment B (Tables B-1 and B-3), for the assumptions outlined above, the “base” project cost (without risk) was developed from QDOT’s latest cost estimate and allocated to the activities in the D/B standard simplified project flowchart, to create a simple cost-loaded schedule. QDOT’s project cost estimate was first reviewed and de-biased, removing any contingency. The base total project cost (through delivery, without contingency) is approximately $16.4 million in current (uninflated) dollars. By major project component or phase, the base costs (in current uninflated dollars) are approximately as follows:

- For capital project delivery:
  - $1.2 million for QDOT pre-construction effort (including preliminary design, contract procurement, environmental documentation, and permitting)
  - $2.0 million for right-of-way acquisition
  - $1.0 million for utility relocations,
  - $11.9 million for D/B design and construction plus QDOT contract administration
- For post-construction:
  - Operations & maintenance costs average about $0.5 million per year

  - Replacement costs are about the same as the current project delivery costs ($16 million).

On average, mean Inflation is about 3.0% per year for engineering, 3.0% per year for ROW and 3.0% per year for construction. Mean extended overheads (i.e., delay costs) associated with schedule delays are about $0.10 million per month for pre-construction and about $0.23 million per month during construction, based on average “burn rates”.

2.4 Base Project Disruption

As presented in Attachment B (Tables B-2 and B-3), for the assumptions outlined above, QDOT estimates its total disruption (through replacement) at about 2.8 million hours (M-hr). By major project component or phase, the mean disruptions are determined (considering how much of that phase experiences disruption, how many people are affected during disruption, and their impact) approximately as follows:

- Utility relocation: 0.2 M-hr
- Construction: 0.5 M-hr
- Operations & maintenance: 1.4 M-hr
- Replacement: 0.7 M-hr

2.5 Tradeoffs

As presented in Attachment B (Table B-3), QDOT has established the following “tradeoffs” for combining performance (cost, disruption, schedule, and longevity):

- The “value” (or user costs) of disruption (in terms of how much QDOT is willing to pay now to avoid disruption) is about $10 per person-hour.
- The “value” of the planned completion date (in terms of how much QDOT is willing to pay now to prevent delay) is about $0.1 million per month.
- The “value” of longevity (in terms of how much QDOT is willing to pay now to prevent discounted longevity costs) is about $1.00 per NPV$.
- The net long-term (during operations and replacement) discount rate (for determining longevity NPV$) is about 5.0% per year.

2.6 Base Project Performance Analysis

As presented in Attachment B (Table B-3), the following mean base project performance measures were determined (using an MS Excel template) based on the D/B standard simplified project flowchart (Figure 2-1) using mean input values (as discussed above):

- Mean base project schedule (start and end dates, float)
- Mean base project cost (both uninflated and inflated) through construction
- Mean base project disruption through construction
- Mean base project “longevity” (combined measure of post-construction project cost, schedule and disruption)
- Mean combined project performance (combined measure of cost, schedule, and disruption through construction, and post-construction longevity, for subsequently determining “severity” of risks)

It should be noted that the mean base performance produced by quantitative risk analysis might differ from that produced by the template for several reasons: a) the quantitative risk analysis is typically done in more detail; and b) the means of the input ranges used in quantitative risk analysis might differ from the directly assessed mean inputs used in the template.

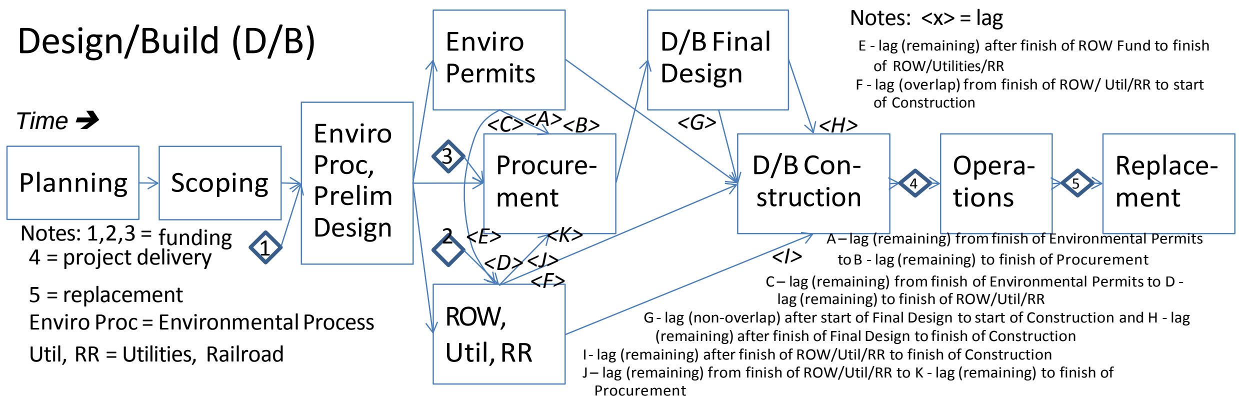


Figure 2-1. Standard Simplified D/B Flowchart for QDOT's US 555 / SH 111 Mean-Value Risk Assessment

3.0 RISK IDENTIFICATION AND ASSESSMENT – BEFORE MITIGATION

3.1 Assumptions and Exclusions

Assumptions are necessary for any analysis, and the results of the analysis must clearly state the assumptions on which they are based. Risk assessments attempt to include all relevant issues so that the results are as inclusive and robust as possible (i.e., the results will "stand the test of time"). The more risks that are excluded, the more "constrained" or "conditional" the results are. However, in many cases an owner has good reason to exclude particular issues from the analysis. The major assumptions for (and exclusions from) this risk assessment are shown in the bulleted items below. <u>All results presented in this report are conditional on these assumptions being true</u> (unless noted specifically).

- Uncertainty in the timing or availability in funding (e.g., cash-flow constraints or contractor financing) was excluded. These issues could be addressed with separate model scenarios.
- "Project-cancelling" risks were excluded (e.g., significant change in purpose and need).

In other words, the question being addressed is, "How much will the project cost and how long will it take if it is funded and completed as currently planned?"

3.2 Risk Register – Before Mitigation

In a facilitated environment, the project team and project-independent subject matter experts identified a comprehensive, non-overlapping set of risks and opportunities relative to the project "base", first by brainstorming and then by categorizing/editing/adding. These risks to project cost, schedule, and disruption were documented in the "risk register".

Each risk and opportunity is defined by several "risk factors":

- the cost, duration, and/or disruption changes to specific flow chart activities (i.e., the "impact scenario") <u>if</u> the risk occurs; and
- the probability of occurrence (as defined by the impact scenario), recognizing that the chance that the risk event does not occur (i.e., no impacts) equals 1.0 minus the probability of occurrence.

The group (by consensus) characterized each of these risk factors in a "mean-value" (i.e., probability-weighted average) sense, via either mean values (e.g., in dollars and months) or pre-defined mean risk ratings (e.g., H, M, L). These factor assessments were also documented in the risk register.

The full risk register (before mitigation) and associated risk-factor rating scales are presented in Attachment C:

- Table C-1 presents the risk-factor rating scale definitions (from the Microsoft Excel template); and
- Table C-2 presents the risk register, in terms of a categorized list of risks (from the Microsoft Excel template) that has been edited and added to so that the list is comprehensive and non-overlapping, and their mean-value or mean rating factor assessments before additional mitigation (from the Microsoft Excel template).

Note that a mean-rating or mean-value risk assessment approach (as used here) provides single mean values/ratings of project performance, essentially ignoring uncertainties and correlations among those uncertainties. To formally address such uncertainties and correlations, and produce ranges (probability distributions) rather than single mean values, a quantitative risk analysis should be conducted.

4.0 RISK ASSESSMENT RESULTS – BEFORE MITIGATION

The base performance factors (as summarized in Chapter 2) and the risk factors before mitigation (as summarized in Chapter 3) were appropriately combined (using the MS Excel template) to determine the following:

- Approximate mean values of base+risk project performance before any additional mitigation, including:
    - Project schedule (duration, start and end dates, and float by activity, and key milestone dates)
    - Project cost (unescalated and escalated, by activity and collectively
    - Project disruption (by activity and collectively)
    - Project longevity (combination via tradeoffs of post-construction schedule, cost and disruption)
    - Project combined performance (combination via tradeoffs of escalated project cost, schedule and disruption through construction, and longevity).
- Mean "severity" of each risk, in terms of its contribution to mean combined project performance before any additional mitigation, and ranking of risks on that basis. Severity is an expression of how much QDOT would logically be willing to pay (on average, for various reasons) to eliminate that risk.

These results are presented in Attachment D:

- Unmitigated base+risk project performance is presented in Table D-1. However, these mean values of project performance are very approximate (for various reasons) and should be used with caution. More accurate results would require quantitative risk analysis, which is currently outside the scope of this *Risk Management Plan*.
- The top risks are presented in rank order of mean severity, both in tabular form (Table D-2) and graphically (Figure D-1). The mean severity and ranking of all risks are presented in Attachment I.

5.0 RISK REDUCTION PLANNING

In a facilitated environment, the project team and project-independent subject matter experts:

- First identified possible ways to reduce the significant risks (and exploit the significant opportunities), as discussed in Chapter 4; and
- Then, assessed (by consensus) the various factors that define the cost-effectiveness of each action in reducing risks (or exploiting opportunities) and thereby improving project performance. These factors include:
    - Mean changes in the base factors (cost, schedule and disruption by activity) associated with implementing the action (regardless of effectiveness), e.g., action A will cost about $1.0M to implement, and
    - Mean changes in the risk factors (cost, schedule, and disruption impacts by activity, and probability of occurrence) as a result of that action, e.g., action A will reduce the probability of risk R occurring by about 1/2.

These actions, and their assessed factors, were documented in the "risk reduction plan".

The cost-effectiveness of each action was then determined (in terms of its net change in combined project performance) by appropriately combining the above information (along with tradeoffs, using the MS Excel template). Cost-effective actions were then selected and plans developed for them, including responsibility and schedule for completion.

The risk reduction plan is presented in Attachment E:

- The possible risk reduction actions for the highest ranking risks are identified in Table E-1.
- The assessed cost-effectiveness factors for each action are documented in Table E-1.
- The calculated (using the MS Excel template) cost-effectiveness of each action is presented in Table E-2.
- The selected cost-effective set of actions, and plans for implementing them, are presented in Table E-3.
- The calculated (using the MS Excel template) mitigated Risk Register (in terms of mean value/ratings) for the selected set of actions is presented in Table E-4.

6.0 RISK ASSESSMENT RESULTS – AFTER MITIGATION

The base performance factors (as summarized in Chapter 2) and the mitigation implementation and risk factors after mitigation (as summarized in Chapter 5) were appropriately combined (using the MS Excel template) to determine the following:

- Approximate mean values of base+risk project performance considering additional mitigation, including:
  - Project schedule (duration, start and end dates, and float by activity, and key milestone dates)
  - Project cost (unescalated and escalated, by activity and collectively
  - Project disruption (by activity and collectively)
  - Project longevity (combination via tradeoffs of post-construction schedule, cost and disruption)
  - Project combined performance (combination via tradeoffs of escalated project cost, schedule and disruption through construction, and longevity).
- Mean "severity" of each risk, in terms of its contribution to mean combined project performance considering additional mitigation, and ranking of risks on that basis. Severity is an expression of how much QDOT would logically be willing to pay (on average, for various reasons) to eliminate that risk.

These results are presented in Attachment F:

- Mitigated base+risk project performance is presented in Table F-1. However, these mean values of project performance are very approximate (for various reasons) and should be used with caution. More accurate results would require quantitative risk analysis, which is currently outside the scope of this *Risk Management Plan*.
- The top risks are presented in rank order of mean severity, both in tabular form (Table F-2) and graphically (Figure F-1). The mean severity and ranking of all risks are presented in Attachment I.

7.0 CONTINGENCY MANAGEMENT

Contingency funds and float are needed on top of the base cost and schedule, respectively, to adequately cover (with appropriate confidence) the risks that actually occur during a project. Cleary, such contingencies generally cannot be based on worst-possible-case assumptions, because that would usually be unaffordable (e.g., commit too much money and time, possibly starving other projects). Instead, a “reasonable” level of confidence is needed, appropriately reflecting the “pain” of exceeding available contingency, i.e., the more pain involved, the higher the confidence level should be. In the past, cost contingencies have often been based strictly on judgment (with industry guidance), as a percentage of the project cost; however, such empirically-derived contingencies have often proven to be inadequate, although occasionally they prove to be excessive. Often, there is no explicit schedule contingency, resulting in missed milestones.

The amount of cost and schedule contingency needed for each phase would ideally be developed by quantitative risk analysis, in which the uncertainty in project cost and schedule would be determined and the values associated with a specified confidence level (which would be a QDOT policy issue) could be identified. In the absence of such analyses, judgment must be used. Hence, the contingency required for this project through each project phase was identified in a facilitated workshop with the project team and project-independent subject matter experts, considering the risks for each phase (see Attachment G).

Specific protocol has been established for managing contingency expenditures and release (see Attachment G).

8.0 RECOVERY

Various actions can be taken throughout project development if contingency becomes insufficient. For example, if remaining schedule contingency has become (or is becoming) insufficient to cover the remaining risks, work can sometimes be accelerated (albeit at a premium price) by working more or longer workshifts or critical path scope can be deferred (e.g., through contract options). As another example, if remaining cost contingency has become (or is becoming) insufficient, then generally either additional funds must be obtained (e.g., from program reserve) or some scope must be deferred (e.g., through contract options).

The amount of recovery needed for each phase would ideally be developed in the same way as contingency should be, i.e., by quantitative risk analysis. In the absence of such analyses, judgment must be used. Hence, the recovery required for this project through each project phase was identified in the same facilitated workshop with the project team and project-independent subject matter experts as for establishing contingency, considering the risks for each phase (see Attachment H). The recovery actions (and their approximate net recovery value) that are available and that satisfy the requirements for this project through each project phase were identified in a facilitated workshop with the project team and project-independent subject matter experts (see Attachment H).

Specific protocol has been established for implementing the recovery plans (see Attachment H).

9.0 IMPLEMENTATION

In order to successfully implement this *Risk Management Plan*, and thereby realize improved project performance, the following is required:

- DOT commitment to the *Risk Management Plan*.
- Designated Project Risk Manager, with adequate authority and resources to carry out this *Risk Management Plan* to:
  - monitor and periodically update the *Risk Register*, i.e., regarding changes in risk factors and in associated results
  - monitor and periodically update this *Risk Management Plan*, i.e., regarding:
    - status/progress and results of selected risk reduction actions, and possible redirection,
    - adequacy of remaining contingency, and recommendations regarding contingency management and implementation of recovery plans
    - status/adequacy of recovery plans

  Monitoring is typically done via short interviews with select project staff (e.g., as part of weekly or monthly project progress meetings), whereas updating requires additional effort (e.g., short workshop).
- Adequate information systems to support implementation of his *Risk Management Plan*, e.g., regarding gathering, interpreting and distributing relevant information

10.0 CONCLUSIONS

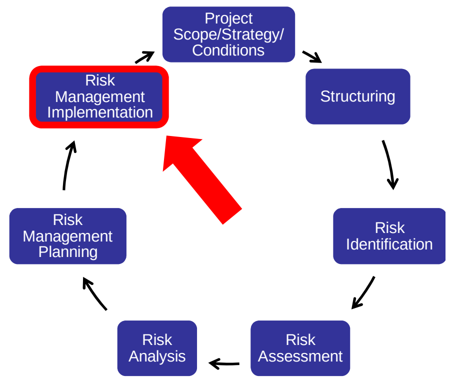
A suitable *Risk Management Plan* has been defensibly developed for the QDOT US 555 / SH 111 project to improve and control project performance (i.e., schedule, cost and disruption through construction and post-construction longevity). This plan consists of three main elements:

- A program of actions intended to proactively and cost-effectively reduce the significant project risks, where the risks were meaningfully evaluated in terms of their “severity” with respect to the project’s combined performance (combination via tradeoffs of schedule, cost and disruption through construction and post-construction longevity).
- Establishment and management of cost and schedule contingency throughout project development to cover the remaining risks (collectively) with a high level of confidence.
- Establishment and management of recovery plans throughout project development in case the remaining contingency is insufficient.

In addition, the requirements for successfully implementing this *Risk Management Plan* have been identified, e.g., organizational structure and resources.

<this page left intentionally blank>

Module 8:
Implementing the Risk Management Plan and DOT Risk Management Program



8-1

Implementing the Risk Management Plan

- **Learning Outcomes**
- Process
- Discussion
- Summary

8-2

Learning Outcomes

- Implement the Risk Management Plan (RMP)
- Monitor and update the RMP according to changing conditions and mitigation strategies
- Adjust contingency and recovery according to RMP implementation and updates
- Describe the implementation of the risk management program
- Identify the necessary resources to implement the risk management program

8-3

Learning Outcomes (cont.)

- Identify the necessary steps and logistics to implement the risk management project level process
- Identify the appropriate staff within the DOT to implement the risk management project level process

8-4

Implementing the Risk Management Plan

- Learning Outcomes
- **Process**
- Discussion
- Summary

Process of Implementing RMP

- RMP consists of:
  - Plans for proactively mitigating specific risks
  - Contingency management
  - Recovery decisions

Process of Implementing RMP (cont.)

- To implement plan, need to establish:
  - Responsibility (e.g., project manager, risk manager, project team)
  - Authority and resources
  - Commitment
  - Communication process and tools

8-7

RMP: An Evolving Document

- Project conditions change with time:
  - Additional project development
  - Proactive risk mitigation
  - Other changes in conditions
- Risk Management Plan needs to:
  - Accommodate changing conditions
  - Be updated based on new information

8-8

Monitoring and Updating

- Monitor and update changing project conditions which include but are not limited to:
  – Project development status
  – Risk mitigation action status and results
  – Residual risks
  – Contingency and recovery plans
- Monitor and update periodically, and document at milestones, and at major project changes

8-9

Monitoring and Updating

Example #1:

RU(1), The project team has determined it will be more cost effective to design around an area with a significant right-of-way risk

Risk Mitigation Implementation Plan

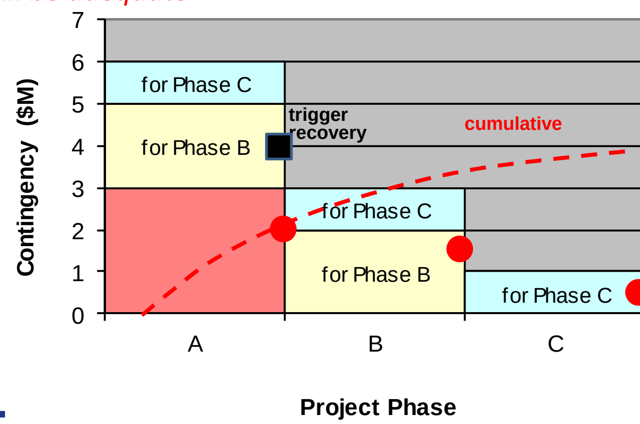
Rank	Selected Risk Mitigation Actions (see Risk Mitigation Evaluation for details) (add rows as needed)	Responsibility	Schedule or Milestone Check	Comments
1	RU(1). The team will design around areas where right of way may be an issue, specifically at US-555 & SH-111 junction.	Design lead, in conjunction with right-of-way lead.	By end of preliminary design.	Need to get approval for design deviations.

action successfully completed, and risk eliminated
<by *name and date*>

8-10

Monitoring and Updating

- Example #2:
  - 2a. Contingency reserved has increased by *$1.5M* since the last reporting period, leaving *$2.5M* available for the rest of project, which should *still be adequate*
  - 2b.Contin-gency reserved exceeds available, triggering recovery



Implementing the Risk Management Plan

- Learning Outcomes
- Process
- **Discussion**
- Summary

8-12

Discussion - Implementing Risk Management Plan

For any given project discuss:

- Monitor and Update - what/when/how?
- Structure/resources - what organizational structure/infrastructure and resources needed to monitor and update, and to make decisions?

8-13

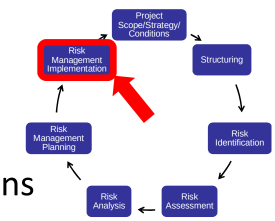
Implementing the Risk Management Plan

- Learning Outcomes
- Process
- Discussion
- **Summary**

8-14

Summary: Implementing the RMP

- Successful implementation of the Risk Management Plan needs to establish:
  - Responsibility/authority
  - Commitment/resources
  - Communication process
- A RMP Involves monitoring and periodic updating of:
  - Project development status
  - Mitigation action and results
  - Residual Risks
  - Contingency and recovery plans



8-15

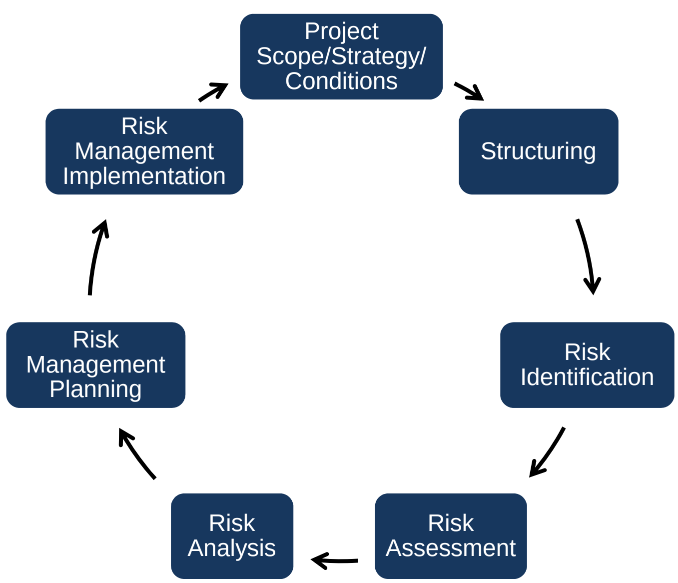
Implementing the DOT Risk Management Program

8-16

Implementing the DOT Risk Management (RM) Program

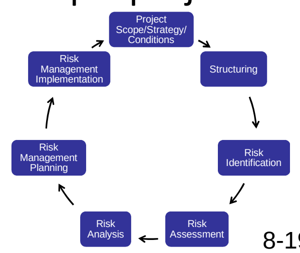
- **Risk Management Quick Review**
- DOT Risk Management Program Development
- Implementation Logistics (Project-level)
- Implementation Steps (Project-level)
- Discussion
- Summary

Risk Management Process



Risk Management

- Optimize project performance (cost, schedule, disruption)
- Formal, structured, iterative, flexible, and efficient process
- Accurate/defensible results
- Training to conduct process on simple projects or supervise on complex projects
- Requires:
  - DOT commitment
  - Accuracy/ defensibility



8-19

Implementing the DOT RM Program

- Risk Management Quick Review
- **DOT Risk Management Program Development**
- Implementation Logistics (Project-level)
- Implementation Steps (Project-level)
- Discussion
- Summary

8-20

DOT Risk Management Program Development

- Policy development
- Procedures development
- Organizational structure design
- Resource needs
- Facilitator training
- Technical support (internal and external)
- Customized/adaptable for each DOT

8-21

Example of Org. Structure

- DOT Management: provide active support, authority, resources, and ultimate responsibility
- Risk Program Manager:
  - Leads/facilitates risk management activities
  - Guides and manages development and implementation of Risk Management Plan (at program level)

8-22

Example of Org. Structure (cont.)

- Risk Workshop/Meeting Facilitator
- Project Manager:
  - Guides and manages development and implementation of Risk Management Plan (at project level)
  - Coordinates risk management workshops and other activities
- Prepared technical resources
  - Project team, estimator, scheduler and SMEs

8-23

Implementing the DOT RM Program

- Risk Management Quick Review
- DOT Risk Management Program Development
- **Implementation Logistics (Project-level)**
- Implementation Steps (project-level)
- Discussion
- Summary

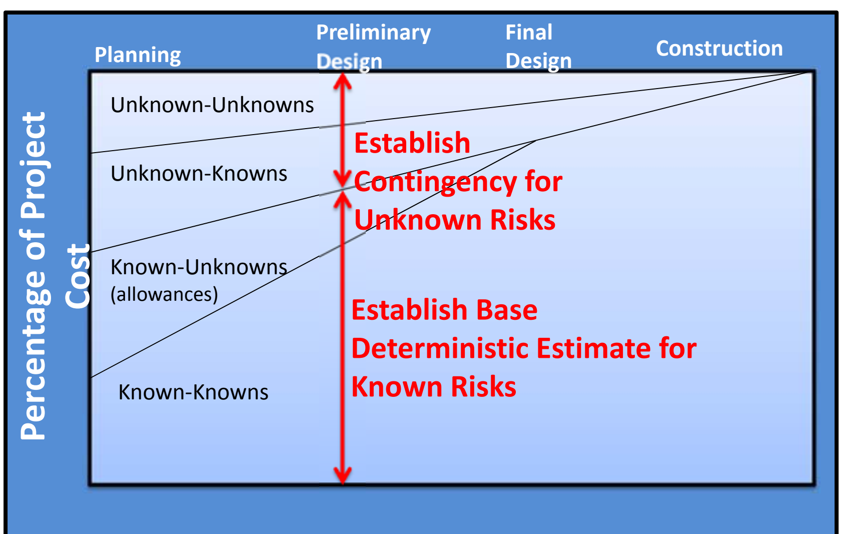
8-24

Implementation Logistics: Timing

- Conduct early in project development to:
  - Determine where within the org. structure, the risk management responsibility exists.
  - Compare alternatives on equal basis
  - Improve project performance by reducing risks
  - Initiate Risk Management Plan
- Update later in project development to:
  - Establish/review budgets and milestones (funding and contingency)
  - Track/update/add risks and opportunities
  - Implement/track *Risk Management Plan*

8-25

Implementation Logistics: Timing



8-26

Implementing the DOT RM Program

- Risk Management Quick Review
- DOT Risk Management Program Development
- Implementation Logistics (Project-level)
- **Implementation Steps (Project-level)**
- Discussion
- Summary

8-27

Implementation Steps (Project-level)

1. Initiate the RM Process
2. Prepare for the RM Meetings/ Workshops
3. Conduct the RM Meetings/ Workshops (Modules 4-7)
4. Document RM Process and Results (Risk Management Plan)
5. Implement Risk Management Plan (Module 8)

8-28

Implementing the DOT RM Program

- Risk Management Quick Review
- DOT Risk Management Program Development
- Implementation Logistics (Project-level)
- Implementation Steps (Project-level)
- **Discussion**
- Summary

8-29

Discussion on Implementing DOT the RM Program

- For your DOT:
  - Should your DOT conduct formal risk management on your projects? Which ones? When? What scope?
  - How should your DOT implement risk management to make it cost-effective for your projects? Who should be involved?
  - What concerns do you have regarding your DOT implementing risk management?

8-30

Discussion on Implementing the DOT RM Program (cont.)

- For Risk Management at project level (meeting/workshop):
  - Who should be invited to participate in meetings/workshop?
  - How long should meeting/workshop be scheduled for?
  - Could you plan and facilitate meetings/workshop?

8-31

Discussion on Implementing the DOT RM Program (cont.)

- For Risk Management at project level (meeting/workshop):
  - Project Scope, strategy, conditions: Risk Facilitator, DOT Project Manager, DOT Project team
  - Structuring: Risk Facilitator, DOT PM, DOT Project team
  - Risk ID: Risk Facilitator, DOT PM, DOT Project team, SMEs
  - Risk Assessment: Risk Facilitator, DOT PM, DOT Project team, SMEs
  - Risk Analysis: Risk Facilitator, DOT PM, DOT Project team, SMEs
  - Risk Management Planning: Risk Facilitator, DOT PM, DOT Project team, SMEs
  - Risk Management Implementation: DOT PM and DOT Project team

8-32

Implementing the DOT RM Program

- Risk Management Quick Review
- DOT Risk Management Program Development
- Implementation Logistics (Project-level)
- Implementation Steps (Project-level)
- Discussion
- **Summary**

8-33

Summary - Implementing the DOT RM Program

- Organizational leader and system to provide
  - Active organizational support
  - Adequate resources and participation
  - Commitment to implement process
- Training and implementation materials
- DOT Qualified Staff:
  - RM Champion (DOT Management) - Risk Program Manager
  - Risk Workshop/Meeting Facilitator - Project Manager
  - Prepared technical resources (team and SMEs)

8-34

Questions?

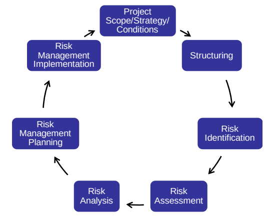
goSHRP2@dot.gov

SHRP2 SOLUTIONS

Save lives. Save money. Save time.

8-35

Chapter 10. Implementing this *Guide*



Adequately but efficiently plan and implement the risk management process described in this *Guide.*

10.1 Introduction to Implementing this Guide

This *Guide* has outlined an efficient and effective process for managing risks on rapid renewal projects. However, adequate planning and logistical support, as provided by an established DOT program, are required for a DOT to successfully implement this process. This chapter summarizes key logistical issues to consider when planning, staffing, and conducting the risk management process, as well as developing a DOT program.

Adequate planning, appropriate resources, careful coordination, and integration into continuous project management processes are the keys to successful risk management implementation. The DOT should initiate the risk management process early in the project's life cycle, and then update as appropriate. The DOT also needs to engage the appropriate participants and provide them with relevant information for each of the risk management process steps. Ultimately, the DOT needs to adequately plan and resource the meetings, workshops, and project management staff throughout the process to ensure an efficient and effective process. A good planner and a qualified facilitator are keys to successful implementation. All the above require an appropriate DOT program, including policy, procedures, and resources.

10.2 Process of Implementing this Guide

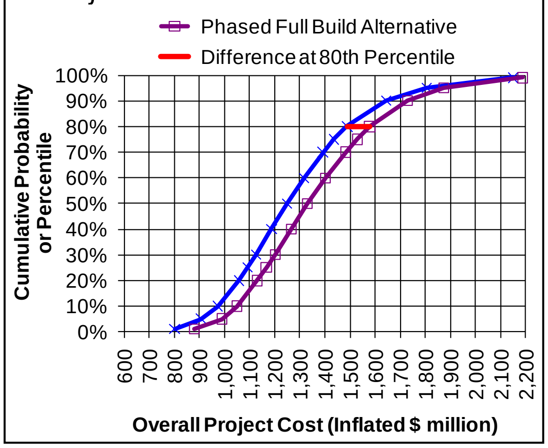
When to Apply this Guide

Risk management is beneficial in all phases of project development. In general, the earlier risk management is started, the more time the project team has to react to the identified risks and the easier the risks are to manage, and thus the more benefits the project will gain from risk management. However, there is such a thing as "too early" to conduct effective risk management for individual projects. This can be true when a program is just being established, but the purpose and overall scope for individual projects have not yet been established.

Once a project's purpose and overall scope have started to take shape, various elements of the risk management process can be applied to maximize benefits. The following guidance applies to large and/or complex projects, or projects with significant specialty elements:

- When a project is in the scoping phase and/or preliminary design (e.g., prior to approximately 10% design) and the DOT has yet to select a preferred alternative, the process can be particularly useful for evaluating the risks of each alternative relative to the other alternatives. The process applied at this point includes: structuring (Chapter 4); risk identification (Chapter 5); risk assessment (Chapter 6); and considering some elements of risk management (Chapter 8), especially proactive risk reduction for significant risks. This comparison can help the DOT make decisions among alternatives, such as design alternatives, funding alternatives, or project-delivery alternatives. If cost and schedule estimates also exist for each alternative at this point in time, risk analysis (Chapter 7) can also be conducted to quantify uncertainty in the cost and schedule for each alternative, which can then be compared among alternatives to help make decisions. An example of this type of comparison for project cost, where one alternative (full build) is about $100 million (or 6%) less than the other (phased full build), is shown here. The corresponding project schedule, disruption and longevity can

Example Comparison of Cost Uncertainty for Project Alternatives:



also be compared in a similar way. At this stage of project development, these elements of the risk management process can be conducted in less detail than would normally be done for a preferred alternative, especially if results are being used only to compare alternatives.

- After the DOT has selected a project alternative (e.g., after completion of environmental documentation, or near 30% design), the original structuring, risk identification, and risk assessment for the preferred alternative (if done previously) can be updated to reflect the greater level of project development. Additional detail can also be included at this stage in order to get a better "picture" of the preferred alternative's risks and opportunities. The DOT can also conduct risk analysis (Chapter 7) in this phase if interested in cost and schedule uncertainty, and in defensible development of contingency to adequately cover those uncertainties. At this point, risk management planning (Chapter 8) and implementation (Chapter 9) are also appropriate and beneficial for the preferred alternative. Again, the earlier in project development that the risk management process can be started, the greater the benefits.
- As the project progresses beyond preliminary design and the environmental process to final design, right-of-way acquisition, and utility relocations; the DOT should update the risk management process. This can be done at key project milestones, at some pre-determined time interval, or both. For example, the US Federal Transit Administration (FTA) has historically required risk management updates at key project milestones, such as entry to final design and application for FTA's funding grant. Other agencies, such as the Washington State DOT (WSDOT), will typically conduct annual updates for its large, complex, or high-visibility projects. When appropriate, risk management can be integrated with Value Engineering (VE), where ways to proactively reduce significant risks or capitalize on VE opportunities can be explored.
- When a project nears construction procurement, some agencies will update the risk management process to develop a validated engineer's estimate (including contingency) and to guide risk allocation for contract-document preparation. The agency could also conduct a more-detailed assessment of construction risks (e.g., management of traffic or construction staging) and plan specific risk management actions for those risks (either individually or collectively), if not done previously. This could be particularly useful for rapid renewal projects, which often employ innovative construction technologies and materials.
- Unless a project has particularly complex construction staging and/or specialty construction, the risk management process during construction usually focuses on continuing to manage previously-identified risks (rather than identifying, evaluating and managing new risks) and on managing contingency. However, there are cases when risk identification and subsequent steps might be conducted (or repeated) during construction. For example, when a major failure has occurred during construction, the owner might want to make sure that the contractor has identified and can effectively manage similar potential problems through project completion.

As previously noted (Chapter 2), the risk management process is easily "scalable" to match project type, size, complexity, and needs. For projects that are not as large or complex, the risk management process should be much simpler, ranging from: a) "very simple" prioritized risk lists and plans (without assessment/analysis); to b) "simplified" mean-value assessments/analysis; to c) "complex" full quantitative uncertainty assessments/analysis. For example, structuring, risk identification, risk assessment, and risk management planning might only be conducted once, although risk management implementation would have to be carried through to the project's completion to gain the maximum benefits. For example, WSDOT has such a policy for any project with an estimated cost between \$25 million and \$100 million.[1]

How to Apply this Guide

The keys to success for the risk management process include proper planning, allocation of appropriate resources, careful coordination, and integration into continuous project management processes. Lack of preparation and focus can grind a group to a standstill, resulting in inefficiency, frustration, and wasted effort. In order to ensure that the risk management process fulfills its potential, the DOT must properly plan and resource the effort. To conduct an effective and efficient risk management process, a DOT should

[1] http://www.wsdot.wa.gov/Projects/ProjectMgmt/RiskAssessment/, accessed August 7, 2009.

conduct the following (see Appendix E for simplified risk management materials, including agendas, presentations, forms and template):

- Regarding <u>leadership and facilitation</u> of the risk management process:
    - *Project leadership should provide a "command emphasis" for the risk management process*. The project leadership has to establish and continually reinforce the need for risk management to ensure that project-team members participate appropriately. Project leadership should also communicate the need for risk management "up the chain" to ensure that the proper external resources (including independent subject-matter expertise) are provided.
    - *Effective facilitation is essential* for efficient and effective meetings and workshops that are inevitably part of the risk management process. A weak or untrained facilitator can cause a meeting or workshop to lose focus and fail. The facilitator should be knowledgeable (in general, but not necessarily with the specifics) about the various phases of rapid renewal projects. The facilitator also needs to be adequately trained in the risk management process and the underlying principles and guidance, and should have practical facilitation experience (preferably for risk management). A few key points on facilitation include:
        - Maintain a positive, engaging presence.
        - Try to achieve consensus, as well as project team buy-in. Be fair by letting all qualified voices be heard equally and don't let strong personalities dominate (bias) the discussion. Encourage participation and responsibility. As long as no adverse group dynamics are at work, follow a policy that "silence is acquiescence".
        - Appropriately consider all available information.
        - As tactfully as possible, keep the group focused – stay on task and on time. If bogged down, stimulate the discussion by asking different questions or asking questions differently ("from a different angle").
        - Always keep in mind the goals for the risk management process – **adequate but efficient**. Keep the level of detail and quality of the assessments appropriate and consistent with the purpose for the risk management process.
        - Try to remain neutral, but don't be a "pushover". The facilitator must be convinced that the assessments are reasonable and bias-free.
- Regarding <u>participation</u> in the risk management process:
    - *Project leadership should actively participate in the risk management process*. Without consistent engagement by the project leadership, the risk management process will falter. Consistent leadership will ensure that the risk management process is carried to its conclusion and that risk management objectives are met. For example, project leaders often must provide key input to the risk management process, as well as make risk-based decisions regarding the project's development. Project staff often does not have the knowledge or authority to make such decisions, which can slow project development and hobble risk management. Project staff does, however, often have information on potential risks and risk management options. Project leaders should invite and encourage the entire team's input into the process.
    - *Participants should be adequately qualified in their respective areas of expertise*. Expertise can come in the form of project expertise (project-team members are experts about the particular project) and subject-matter expertise (discipline experts). A given participant can fulfill more than one role in the risk management process, if qualified to do so. However, the facilitator should tactfully request that participants who are not knowledgeable on a particular topic to refrain from offering opinions on that topic. Unqualified opinions degrade the quality of assessments, as well as reduce the efficiency of the effort.
    - *Participants should include key project team members (including the cost estimator and scheduler) and independent subject-matter experts*. Perhaps the easiest way to avoid bias in the risk management process is to include both project experts and *project-independent* experts. The interaction of these two groups is extremely useful for highlighting potential

project issues and for reaching potential solutions. The independent experts could be the same as used for VE, realizing some efficiency.

- *Participants should be at least minimally trained on the risk management process*, their roles within the process, and on how to perform those roles. Previous chapters in this *Guide* and the companion training course provide a good training basis for participants. Otherwise, the facilitator should provide minimal training at the beginning of the workshop (see Appendix E for an introductory overview presentation that provides such training and should be made at the beginning of a workshop).

- Regarding planning of the risk management process:

  Planning for the risk management process is important and non-trivial. A good checklist, as well as a good planner, can help immensely when planning for the risk management process. The typical planning tasks and logistics considerations for a project risk management process include:

  1. Initiate the Risk Management Process

  - Identify the need and scope, as well as commitment, for risk management – This includes (but is not limited to):
    - Coordinate with the project team;
    - Consider tying risk management and VE processes together at key milestones; and
    - Determine if prioritized lists or qualitative or quantitative analyses are needed (e.g., to quantify project performance uncertainty, from which appropriate budget and contingency can be determined).
  - Identify the funding source and secure funding for risk management - Coordinate with DOT management and the project team, and complete funding administrative requests / actions.

  2. Prepare for the Risk Management Meetings / Workshops

  - Identify the risk management process steps to be covered in a meeting/workshop – The DOT might implement a number of risk management process steps in one meeting (e.g., structuring, risk identification, risk assessment, and risk management planning), or have separate meetings, to suit the needs of the DOT. The DOT might tie risk management and VE together, and/or conduct a separate preparatory session upfront to plan subsequent workshops and meetings, including identification of participants.
  - Implement necessary contracts and task orders (DOT internal and for consultants) - Give sufficient lead time to contracting personnel, and follow up as required.
  - Identify and confirm participants, including facilitator, independent subject-matter experts and project-team members - *Follow up as needed. Iterate when the study schedule changes, or for project risk management updates.* Identify key project issues for which experts are needed (e.g., independent cost estimator and scheduler). Communicate the workshop schedule/agenda, responsibilities, and logistics to all members.
  - Identify the schedule for risk management, including risk management meetings and workshops - *Iterate when member participation and/or facilities change, or for project risk management updates:*
    - Select the format for the workshop (e.g., single, all-encompassing meeting, versus more linear with extended schedule and several, smaller workshops, or even interviews);
    - De-conflict the schedule with other major events involving significant resources or personnel; and
    - Develop a meeting / workshop agenda and distribute to all participants.
  - Identify, schedule, and confirm facilities for risk management meetings / workshops. *Iterate when the study schedule changes* - Visit the facilities prior to the workshop start date to meet the necessary contacts and to assess the facilities. Facilities include:

  - Venue: location, building(s) (including access, after-hours access, and visitors' passes), quiet main meeting room to comfortably accommodate all participants and 1-2 smaller breakout rooms, and parking.
  - Support services and materials: printing and copying; Information Technology (computer network; phone; e-mail); LCD projectors (x2); notebook computer (for technical documentation); projection screen; dry-erase board and markers; paper flipchart and markers; power extension cords (3-prong grounded); daily refreshments; "working" meals; and miscellaneous office supplies.
- Send a risk management workshop "requirements packet" to the project team (i.e., instructions for project-team preparation), such as project description and cost/schedule estimates. Follow up as needed.
- Review and modify the requirements packet as needed, and deliver to the project team as soon as possible.
- Establish and communicate the deadline for project team's response.
- Send project information (with instructions) to independent experts to review beforehand – especially review relevant design and cost/schedule estimate information for subsequent structuring.

3. *C*onduct the Risk Management Meetings / Workshops (per Chapters 4 through 8 of this *Guide*)

- Kick-off the risk management meeting workshop - Ensure that participants' travel schedules are consistent with their required workshop participation. The risk management facilitator should arrive early to set up the facilities and provide an overview of the process (see Appendix E) and develop common understanding of the project.
- Develop consensus on all risk management inputs - Document assessments in real time (e.g., on computer screen using MS Excel template, on whiteboard, etc.). Having a separate note taker working with the facilitator helps immensely for this. Breakout in smaller groups for specialized topics, for which a second facilitator would be needed. Note: A second facilitator also provides redundancy in case something happens to the first facilitator, thereby protecting the large investment made for the workshop. Provide adequate time (e.g., after the workshop) to review and finalize risk management inputs, as well as to subsequently develop/implement the risk model (if needed).
- Prepare a workshop risk management results briefing (if results are to be briefed outside workshop participants) - As early as possible, forecast the briefing schedule and communicate to briefing attendees (especially if not participating in a workshop). For example, the briefing might precede a separate VE workshop.
- Present and discuss risk management results.

4. Document the Risk Management Process and Results

- Prepare and submit a draft risk management report, including Risk Management Plan (which includes the risk register).
- Finalize the risk management report based on feedback from the project team and other workshop participants.

5. Implement the Risk Management Plan (per Chapter 9 of this *Guide*)

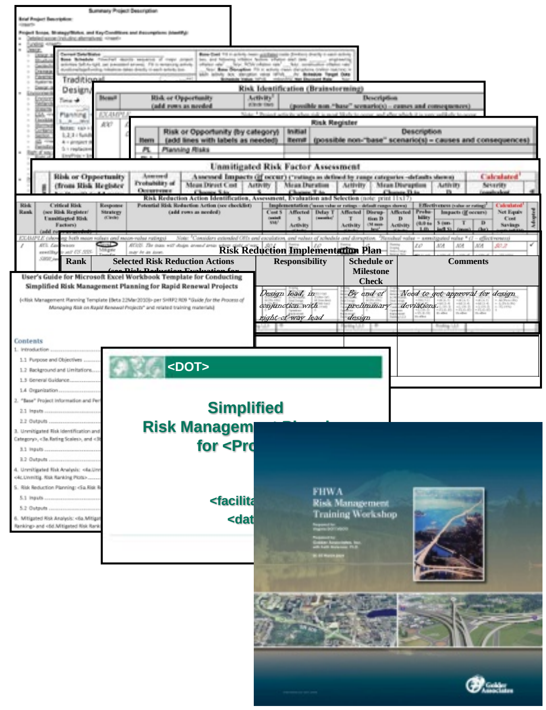
- Ensure DOT commitment and resources.
- Establish responsibility and authority.
- Plan for and conduct monitoring and updates as appropriate (as above), as well as manage contingency.

A separate logistics planner, working in concert with the risk facilitator, can help accomplish the above steps. A three-step process of interacting with the project team has been developed (see Appendix E for agendas and discussion points):

1) 1-hr. conference call to develop cursory understanding of the project and to establish the scope of risk management, as well as to request project information and plan subsequent efforts;
2) 3-hr. webinar to develop good understanding of the project and to confirm abstracted schedule and cost models and base factor assessments, as well as to plan subsequent activities; and
3) Multi-day workshop to finalize models and base factor assessments, to identify risks and assess their factors, and to identify possible risk reduction actions and assess their factors.

Companion Implementation / Training Materials

As previously noted, a qualified facilitator, as well as DOT management and project team commitment, planning, and participation of appropriate project team and independent experts, are key to successful implementation of the risk management process outlined in this *Guide*. A companion training course for this *Guide* has been developed especially to train DOT facilitators to conduct important parts of the risk management process described in this *Guide* on relatively simple projects (see Appendix G). Also, forms and an MS Excel workbook template have been developed (and are included in the training) to help the facilitator conduct the important aspects of risk management on simple projects (see Appendix E). This training is also useful for DOT management and potential participants, including key project team members and independent experts (e.g., from DOT headquarters), to help them better understand the process. However, this training is not required for everyone who participates in the risk management process. Typically, the facilitator will provide a short overview of the process at the start of a workshop to adequately explain the process for the participants, and it will be up to the facilitator to subsequently guide the participants through that process. Such an overview presentation has been developed and is provided (see Appendix E).



Agendas, Overview Presentation, Forms and Template (Appendix E) and Training (Appendix G)

The training course is two days long, in which a hypothetical (but realistic) DOT rapid renewal project is evaluated for illustration and concept reinforcement. The class consists of individual modules, generally one for each chapter in this *Guide*. However, whereas this *Guide* focused on the concepts ("*what*"), the class focuses on the implementation ("*how to*") and includes simple exercises and examples to accomplish this. Notes, in the form of annotated versions of all the slides shown in the class, provide additional details to what is provided in this *Guide*. The focus is on structuring, risk identification, risk assessment (including risk severity analysis and prioritization), risk management planning and risk management implementation, especially for relatively simple projects that a DOT can evaluate in-house, which will help to optimize the performance of those projects.

The class does *not* include detailed training in full quantitative risk analysis (Chapter 7) to quantify the uncertainty in project performance, which can be used to defensibly establish budgets and milestones (and contingencies). Such analyses require specialized skills that cannot be developed in a two-day class. Instead the training will allow a DOT to effectively supervise such analyses, as well as supervise the evaluation of more complex projects.

As previously noted, to help the facilitator conduct selected parts of the risk management process on relatively simple projects, specific forms have been developed to guide and document information developed in the workshop. In addition to hard copy forms (in PDF), these forms have also been replicated in an MS Excel workbook template for data entry and subsequent automatic analysis of that information. Such analyses include determination of:

a) the mean values of base and total (“base + risk”) performance measures;
b) the severity (in terms of combined change in total performance measures) of each risk and opportunity, based on which they are prioritized; and
c) the cost-effectiveness of possible risk-management actions, based on which such actions can be recommended and resulting revised mean values of total performance measures are determined.

The training covers the use of these forms and template.

DOT Risk Management Program

An internal DOT risk management program is needed in order to conduct project risk management, as well as “enterprise” (corporate) and “programmatic” (portfolio of individual projects) risk management. However, such enterprise and programmatic risk management is outside the scope of this *Guide*. Such a DOT program should include:

- *Policy* – DOT commitment, authority and requirements, based on project attributes (e.g., size and complexity);
- *Procedures* – established/approved methods for meeting requirements (per the guidance in this *Guide*);
- *Organizational structure* – specific roles and responsibility/authority, including program management, qualified risk facilitators/analysts, and logistics specialists, as well as access to technical support (e.g., regarding key technical discipline experts, cost estimators, and schedulers); and
- *Resources* – includes funding, staff, training, tools (including information systems, e.g., regarding cost estimate data bases), etc.

Such a program should be customized and adapted for each DOT, depending on its needs and current organizational structure and capabilities. For example, a DOT risk management program office might be: a) separate from, or combined with, the analogous DOT VE program office; b) singularly centralized or dispersed among district offices; and c) staffed full-time or part-time.

10.3 Conclusions regarding Implementing this Guide

The risk management process presented in this *Guide* has the potential to greatly improve the ability of project leadership and team members to make critical decisions, as well as improve project performance with respect to the rapid renewal objectives. However, the process must be adequately planned and resourced, and followed through to its completion, to obtain these benefits in an efficient way. The following are keys to success:

- Prepared technical resources (i.e., project-team and project-independent experts) to brainstorm and provide assessments;
- A (preferably two) qualified facilitator/analyst to ensure an accurate, defensible and efficient process;
- A good planner for logistics;
- An organizational leader and program (including established policy and procedures) to provide:
    - Active organizational support (including information system),
    - Adequate resources and participation, and
    - Commitment to implement the process.

This chapter has provided some important guidance on the logistics of the risk management process, including when and how to apply the process, to help ensure that the DOT realizes the full benefits of risk management. Additional guidance is provided in companion materials (see Appendix E), including training materials, agendas/scripts, workshop introductory overview presentation, and specific forms and an MS Excel workbook template. Guidance is also provided for developing a suitable internal DOT risk management program to efficiently conduct this work.

Illustrative Example

The hypothetical QDOT case study (see Appendix F), which is used throughout the *Guide* to adequately illustrate the various steps of the risk management process and includes a *Risk Management Plan (RMP)*, involved implementation of the risk management process on this project (as described in *Guide* Chapters 2-9). This case study followed the principles and process outlined in this chapter, as documented in the *RMP* and summarized below.

QDOT, through their established risk management program, did the following (as documented in the *RMP*):

- Assembled relevant project information (i.e., regarding scope, strategy/status, conditions/assumptions, cost estimate, schedule, etc.);
- Convened a group of key project-team staff and independent subject-matter experts from the key project disciplines, in a series of workshops facilitated by a qualified risk elicitor/analyst from their risk management program office. This group was convened to conduct risk assessment and risk management planning, culminating in an *RMP* (including the *risk register*); and
- Assigned a Risk Manager (with appropriate authority and resources) to implement the resulting *RMP*, including monitoring/updating/recommending project risks, risk reduction plans, contingency and recovery.

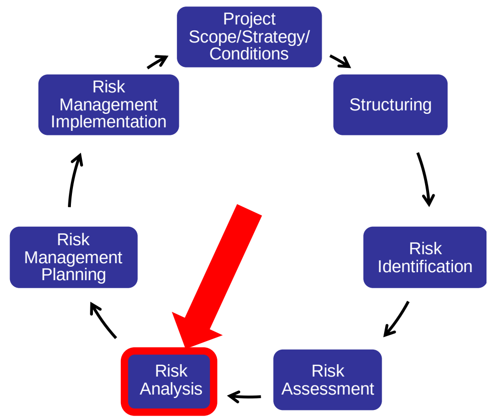
This process was well planned, supported by management, and adequately resourced. Adequate support and resources (including an organizational structure) were then provided to implement that plan throughout project development.

Construction of the QDOT project was successfully completed on 31 January 2013 at an inflated cost of $22.0M (with $2.0M remaining cost contingency and 2.0 months remaining schedule contingency), with few unanticipated problems and no recovery actions.

Performance of QDOT US 555 / SH 111 Project

Project Performance	Base	Base + Contingency	Actual	Unused Contingency
Cost (YOE$M)	$17.0M	$24.0M	$22.0M	+$2.0M
Schedule (mos)	35.0 mos	40.0 mos	38.0 mos	+2.0 mos

Module 9: Overview of Probabilistic Risk Analysis



9-1

Probabilistic Risk Analysis

- **Learning Outcomes**
- Mean Value vs. Probabilistic Risk Analysis
- Describing Uncertainty and Allowances
- Probabilistic Risk Analysis Basics
- Summary

9-2

Learning Outcomes

- Define Probabilistic Risk Analysis (PRA)
- Explain the basics and benefits of PRA

9-3

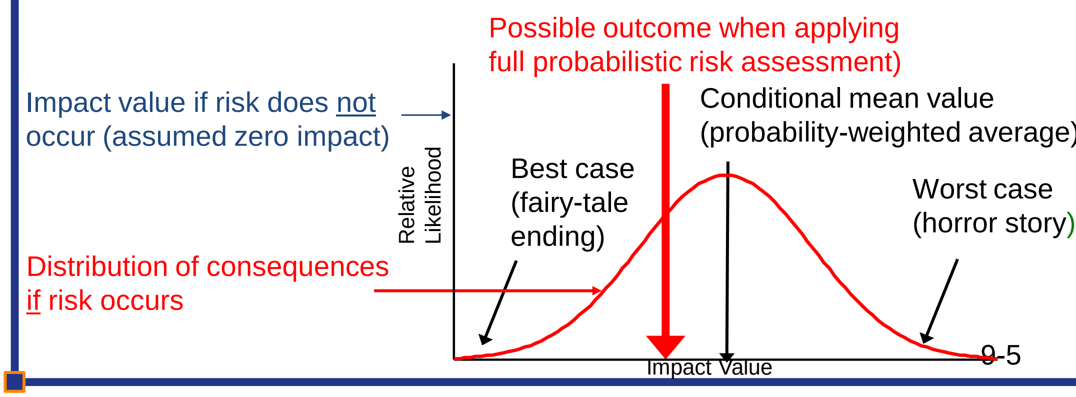
Probabilistic Risk Analysis

- Learning Outcomes
- **Mean Value vs. Probabilistic Risk Analysis**
- Describing Uncertainty and Allowances
- Probabilistic Risk Analysis Basics
- Summary

9-4

Mean Value vs. Probabilistic Risk Analysis

- Mean value represents central tendency of all possible outcomes
- Probabilistic Risk Analysis represents distribution of all potential outcomes (including uncertainty)



9-5

Probabilistic Risk Analysis

- Learning Outcomes
- Mean Value vs. Probabilistic Risk Analysis
- **Describing Uncertainty and Allowances**
- Probabilistic Risk Analysis Basics
- Summary

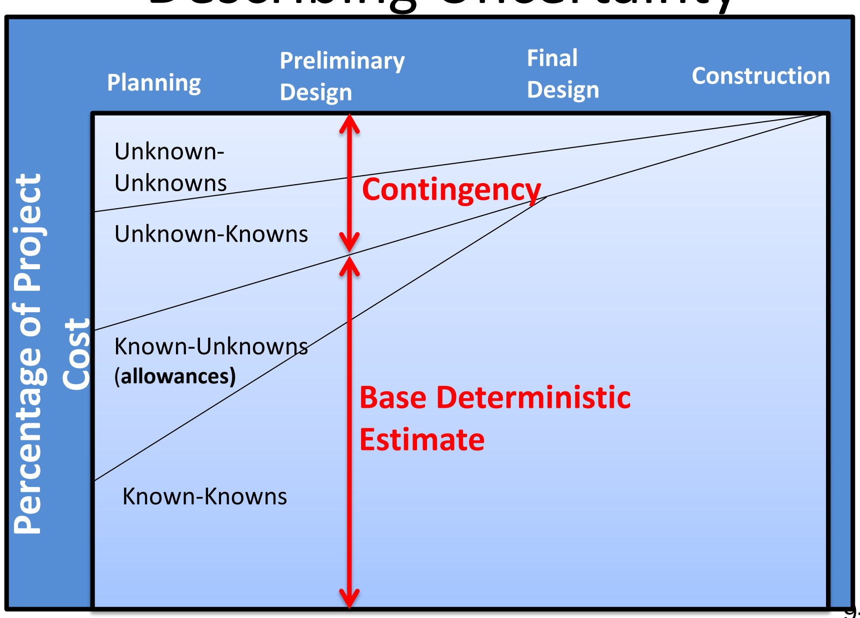
9-6

Describing Uncertainty

“We know it is going to happen” **Known Knowns**	“We expect it to happen, but do not have enough information to quantify it yet.” **Known Unknowns** **(ALLOWANCES)**
Unknown Knowns (RISK REGISTER/CONTINGENCY) *“It might happen, but at least we know about it”*	**Unknown Unknowns** *“We didn’t see that coming!”*

9-7

Describing Uncertainty



9-8

Describing Allowances

- Base Estimate
  - Deterministic
  - Allowances
  - Allowance for Changes during Construction
- Risk Register
  - Contingency removed and turned into Risk Events (Threats and Opportunities)

9-9

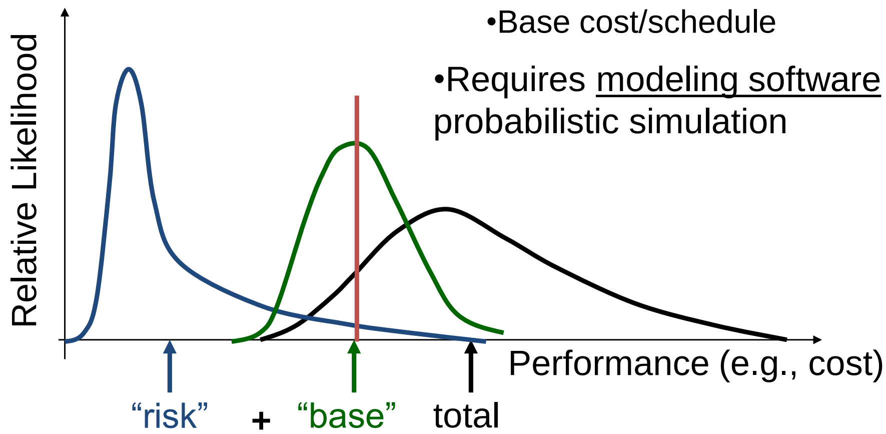
Probabilistic Risk Analysis

- Learning Outcomes
- Mean Value vs. Probabilistic Risk Analysis
- Describing Uncertainty and Allowances
- **Probabilistic Risk Analysis Basics**
- Summary

9-10

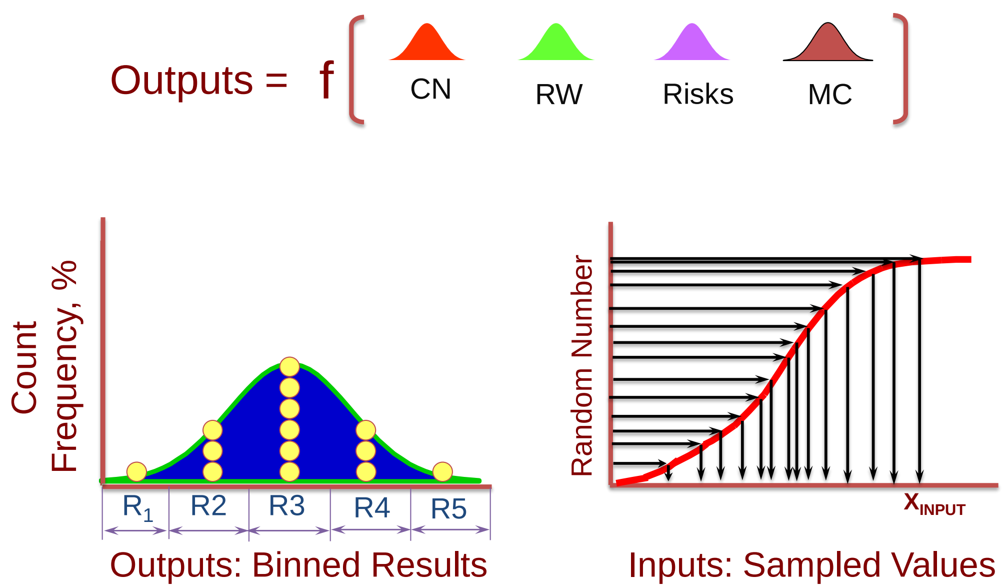
Risk Based Approach
(Probabilistic)

- Accounts for uncertainty
  - Risk/opportunity
  - Base cost/schedule
- Requires modeling software for probabilistic simulation



9-11

Monte-Carlo Simulation



Probabilistic Risk Analysis Steps

1. Define desired results (cost, schedule, etc.)
2. Define project “base” (exclusive of risks)
3. Identify risks and opportunities (relative to base)
4. Quantify “inputs” (base / risk uncertainties)
5. Implement model to determine:
   a. uncertainty in outputs
   b. sensitivity of outputs to inputs
6. Document/check and update (as needed)

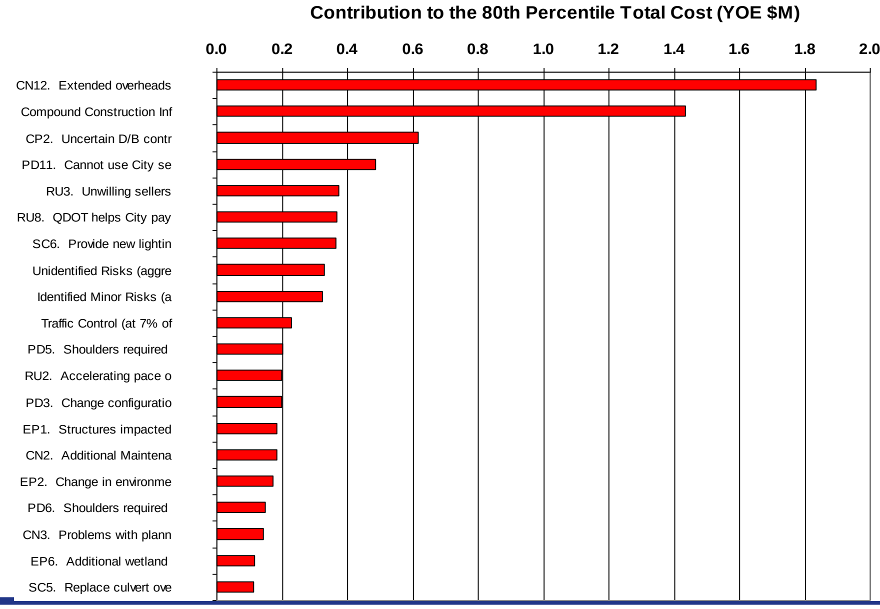
9-13

Probabilistic Model

- Develop risk-based, probabilistic (Monte Carlo simulation) integrated schedule and cost model
- Cost-loaded schedule (by flowchart activity)
  – Duration and unescalated cost of each activity
    Total = Base + Risk
  – Escalation, extended OHs, etc.
- MS Excel with Monte Carlo software

9-14

Probabilistic Results
(risk ranking plots or tornado diagram)



9-15

Probabilistic Results

	Total Project Cost (2009 $M)	Total Project Cost (YOE $M)	NTP Date	Project Completion Date
Base	16.4	17.3	Aug 2011	Nov 2012
		5.40%		
Mean	20.58	21.96	Sep 2011	Jun 2013
Std Dev	2.5	2.9	2.6	2.9
Min	12.8	13.4	Jun 2011	Sep 2012
Max	32.1	35.2	Jul 2012	Jun 2014
1%	15.0	15.8	Jun 2011	Sep 2012
5%	16.5	17.3	Jun 2011	Nov 2012
10%	17.4	18.4	Jun 2011	Mar 2013
20%	18.5	19.6	Jul 2011	Apr 2013
25%	18.9	20.0	Jul 2011	May 2013
30%	19.2	20.4	Jul 2011	May 2013
40%	19.9	21.2	Aug 2011	Jun 2013
50%	20.5	21.9	Sep 2011	Jun 2013
60%	21.1	22.6	Sep 2011	Jul 2013
70%	21.8	23.4	Oct 2011	Aug 2013
75%	22.2	23.8	Oct 2011	Aug 2013
80%	22.6	24.2	Nov 2011	Aug 2013
90%	23.9	25.7	Dec 2011	Sep 2013
95%	24.9	26.9	Feb 2012	Oct 2013
99%	27.0	29.3	May 2012	Nov 2013
80%/base	37.7%	40.2%	16.7%	28.3%

Establish budget/milestone/ contingency, based on target percentile (70th)

9-16

Probabilistic Documentation

In *Risk Management Plan*, document:

- Project description (including cost and schedule estimates)
- Project flowchart
- Base schedule and base cost factors (uncertainties)
- Risks and risk factors (in *Risk Register*)
- Model Results (performance and sensitivity)

9-17

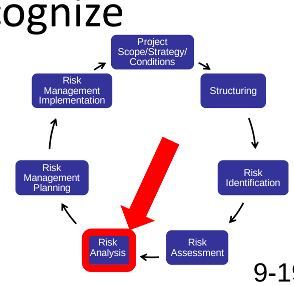
Probabilistic Risk Analysis

- Learning Outcomes
- Mean Value vs. Probabilistic Risk Analysis
- Describing Uncertainty and Allowances
- Probabilistic Risk Analysis Basics
- Example- Probabilistic Risk Analysis
- **Summary**

9-18

Summary

- Quantify uncertainty in project cost and schedule
- Identify steps of Probabilistic Risks Analysis
- Improve decisions
- Adequately document and recognize limitations



9-19

SHRP2
STRATEGIC HIGHWAY RESEARCH PROGRAM

Discussion

Questions?

Thank you!

Please fill out evaluation forms (including feedback)

U.S. Department of Transportation
Federal Highway Administration
AASHTO
THE VOICE OF TRANSPORTATION
TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

9-20

SHRP2 Risk Management Template

HELP **Home**

PROJECT INFORMATION

AGENCY :	Federal Highway Administration	FACILITATOR :	Carlos F Figueroa
LOCATION :	QDOT District 1	PROJECT MANAGER :	Luis Millan
PROJECT NAME :	QDOT Example	DATE :	8/31/2015
PROJECT DESCRIPTION :	QDOT Example R09 Guidebook	VERSION :	1

RISK MANAGEMENT TEMPLATE STEPS

Step 01 - Project Structuring	Enter base project information (schedule, cost, etc.).
Step 02 - Risk Identification	Create list of potential risks.
Step 03 - Rating Scale	Enter values for scales used to assess risk severity.
Step 04 - Unmitigated Risk Assessment	Enter severity information for each risk to assess risk impact.
Step 05 - Unmitigated Risk Register	View unmitigated risks ranked by mean severity value.
Step 06 - Unmitigated Project Performance	View impact of unmitigated risks on project performance and schedule.
Step 07 - Unmitigated Risk Ranking Plots	View graphical ranking of unmitigated risks.
Step 08 - Risk Mitigation Strategies	Enter mitigation strategies for risks selected to be mitigated.
Step 09 - Mitigation Strategies Register	View summary of mitigation strategies selected for each mitigated risk.
Step 10 - Mitigated Risk Register	View mitigated risks ranked by mean severity value.
Step 11 - Mitigated Project Performance	View impact of mitigated risks on project performance and schedule.
Step 12 - Mitigated Risk Ranking Plots	View graphical ranking of mitigated risks.

Project Reset

NOTE: *This will clear all the data from the workbook. Once cleared, the data cannot be recovered!*

Summary Report

NOTE: *Executive or detailed summaries of the analysis can be created by clicking this*

Text Fields	Function
	The grayed out cells in the various modules indicate output cells. These cells cannot be edited by the user.
	The cells that are represented with a yellow background are input cells wherein the user can enter data.
Header	The cells with this formatting (green background and white text) are non-editable header information cells that provide information on what kind of input is required by the user.
Description	Cells with a white background and black text are non-editable description cells that describe information in the input or output cells next to them. These cells may also be used for providing information about the units.
	These cells contain pop-up information to provide the user with extra information regarding the inputs required in this particular field.

SHRP2 Risk Management Template

HELP

Step 01 - Project Structuring

Clear All HOME FWD===>

Create Project

ANALYSIS STEPS

Analysis

Schedule

Lag

Cost

Disruption

OMR

ANALYSIS - Select the "Analysis" button on the left to enter values in the "Analysis" portion of this sheet

Project Delivery Method	Design-Build	Include Operations, Maintenance, & Replacement?	Yes
Selected Perfomance Measures	Schedule		
	Cost		
	Disruption		

SCHEDULE

Project Start Date		12/1/2009
Target Date for Start of Operations	(Open to Traffic Date)	10/30/2012
Schedule Value ($M/month)		0.1

Project Phase	Months/Date	Early Start	Early Finish	Late Start	Late Finish	Float (months)
Planning	0	12/1/2009	12/1/2009	12/1/2009	12/1/2009	0.0
Scoping	0	12/1/2009	12/1/2009	12/1/2009	12/1/2009	0.0
Design Funding Date	12/1/2009		12/1/2009		12/1/2009	0.0
Prelim Design/Environmental Process	12	12/1/2009	11/30/2010	12/1/2009	11/30/2010	0.0
Environmental Permits	6	11/30/2010	6/1/2011	11/30/2010	6/1/2011	0.0
ROW/Util/RR Funding Date	12/1/2009		12/1/2009		11/30/2011	24.0
ROW/Util/RR	12	11/30/2010	11/30/2011	11/30/2010	11/30/2011	0.0
Construction Funding Date	12/1/2009		12/1/2009		11/30/2010	12.0
Procurement	6	11/30/2010	6/1/2011	11/30/2010	6/1/2011	0.0
Final Design	6	6/1/2011	11/30/2011	6/1/2011	4/30/2012	5.0
Construction	16	7/1/2011	10/30/2012	7/1/2011	10/30/2012	0.0
Operations & Maintenance	600	10/30/2012	10/8/2062	10/30/2012	10/8/2062	
Replacement	0	10/8/2062	10/8/2062	10/8/2062	10/8/2062	

SCHEDULE LAG

Include Schedule Lag?	Yes

Schedule Lag Parameters - Description	Months
Lag A - Time remaining from the finish of Environmental permitting to Lag B	0.0
Lag B - Time remaining after completion of Environmental Permitting to finish of Procurement	0.0
Lag C - Lag remaining from finish of Environmental permits to Lag D	0.0
Lag D - Time remaining after the completion of Environmental Permitting to the completion of ROW/Utilities/RR	0.0
Lag E - Time remaining to finish ROW/Utilities/RR after the ROW/Utilities/RR funding date	0.0
Lag F - Time elapsed from the completion of ROW/Utilities/RR to start of Construction	6.0
Lag G - Time elapsed after the start of Final Design to start of Construction	1.0
Lag H - Time remaining after the finish of Final Design to finish of Construction	6.0
Lag I - Time remaining after finish of ROW/UTL/RR to finish of Construction	10.0
Lag J - Time remaining after finish of ROW/Utilities/RR to Lag K	6.0
Lag K - Time remaining from finish of ROW/Utilities/RR to finish of Procurement	0.0

BASE COST (in Current Year and Year of Expenditure Dollars)

Project Phase	Base Cost (CY $M)	Base Cost + Overhead Cost (CY $M)	Base Cost + Overhead Cost (YOE $M)
Planning		0.00	0.00
Scoping		0.00	0.00
Prelim Design/Environmental Process	1.19	1.19	1.21
Environmental Permits		0.00	0.00
ROW/Util/RR	3.00	3.00	3.14
Procurement		0.00	0.00
Final Design		0.00	0.00
Construction	11.85	11.85	12.67
Total	16.04	16.05	17.02

Cost Inflation Rate (percent/year)	
Preconstruction	3.0
ROW/Utility/RR	3.0
Construction	3.0

Overhead Rate	(CY $ M/month)
Preconstruction	0.10
Construction	0.23

,

OPERATION, MAINTENANCE & REPLACEMENT

Facility Performance Period	50.0	years
Discount Rate to convert CY $ to YOE $ (Net Discount Rate)	5.0	%

Facility Asset Type	Asset Life Expectancy (yr)	Operations & Maintenance		Replacement	
		Agency O&M Costs (CY $M/yr)	Disruption (Million-Hr/yr)	Agency Costs (CY $M/event)	Disruption (Million-Hr/event)
Asset 1	50.0		0.028		
Asset 2	50.0				0.700
Asset 3					
Asset 4					
Asset 5					
Total YOE $M		0.0	14.0	0.0	7.0
Total CY $M		0.0	5.1	0.0	6.6

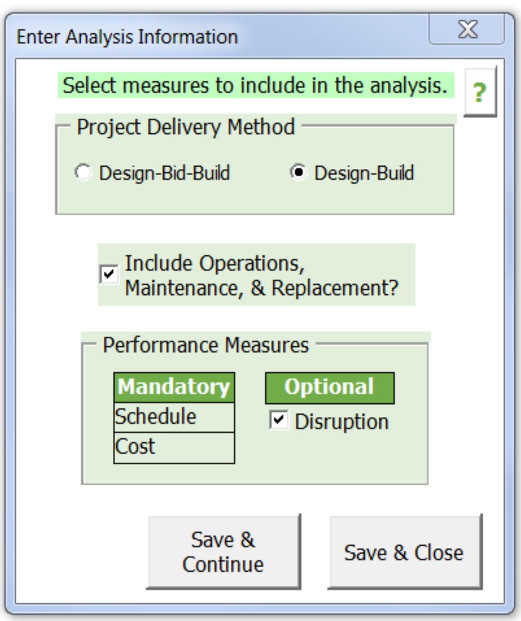
DISRUPTION		
Disruption Value	10	$M/M-hr
Agency/User Cost Discount Factor	1	

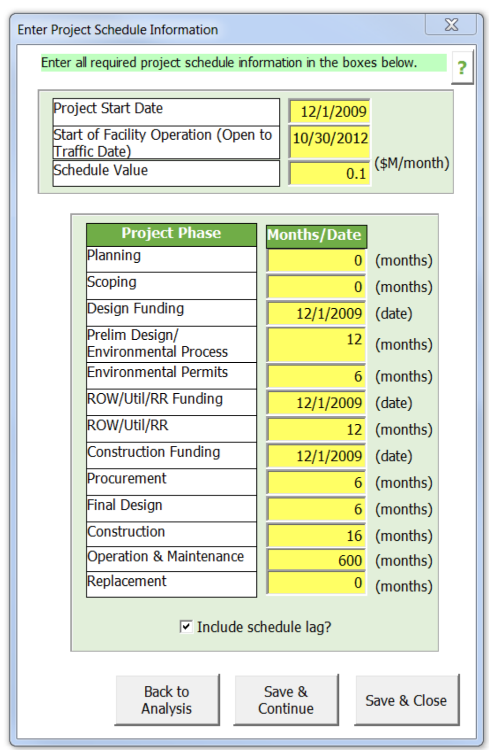
Project Phase	Disruption			
	M Veh-Hours/Day	No. of Days	M-Hrs	Cost ($M)
Planning			0.0	0.0
Scoping			0.0	0.0
Prelim Design/Environmental Process			0.0	0.0
Environmental Permits			0.0	0.0
ROW/Util/RR	0.02	10	0.2	2.0
Procurement			0.0	0.0
Final Design			0.0	0.0
Construction	0.05	10	0.5	5.0
Operations & Maintenance			1.4	14.0
Replacement			0.7	7.0
Total Disruption through OMR			2.8	28.0

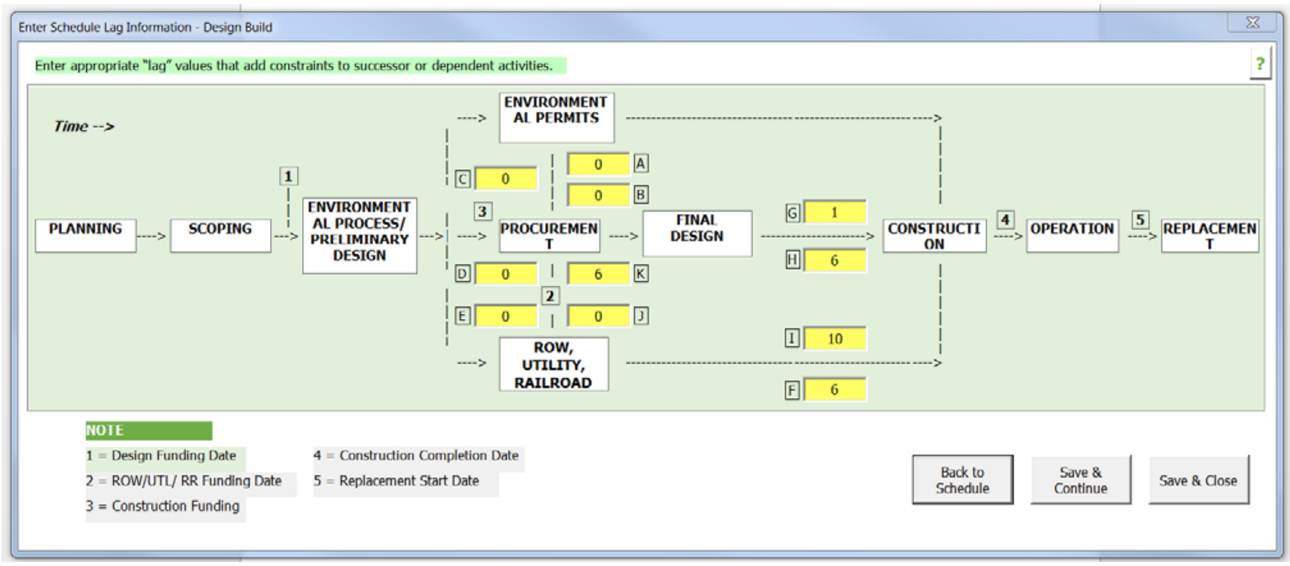
SUMMARY

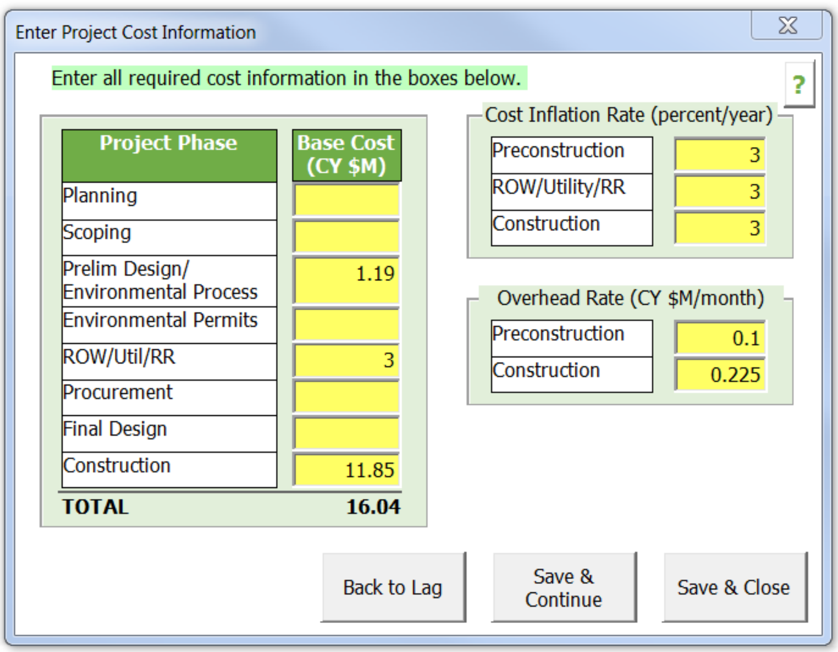
Project Phase	Total CY Cost ($M)	Total YOE Cost ($M)	Duration (months)	Early Start	Early Finish
Planning		0.00	0	12/1/2009	12/1/2009
Scoping		0.00	0	12/1/2009	12/1/2009
Prelim Design/Environmental Process	1.19	1.21	12	12/1/2009	11/30/2010
Environmental Permits		0.00	6	11/30/2010	6/1/2011
ROW/Util/RR	3.00	3.14	12	11/30/2010	11/30/2011
Final Design		0.00	6	6/1/2011	11/30/2011
Procurement		0.00	6	11/30/2010	6/1/2011
Construction	11.85	12.67	16	7/1/2011	10/30/2012
Operations & Maintenance	0.00	0.00	600	10/30/2012	10/30/2062
Replacement	0.00	0.00	0		

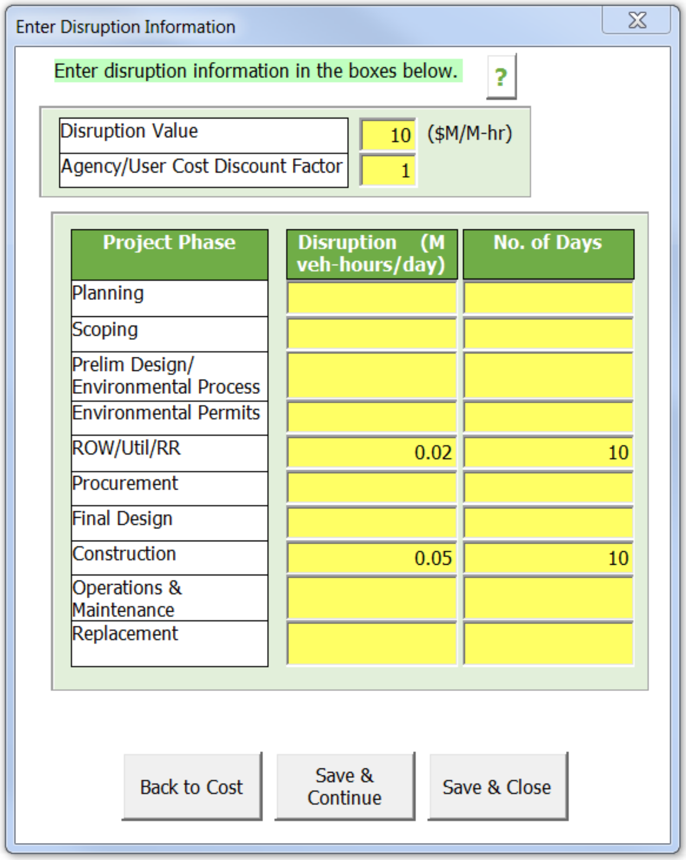
Base Cost (YOE $M)	17.02	(through Operations, Maintenance, & Replacement)
Base Construction Completion Date	10/30/2012	
Months to Construction Completion	35.00	
Base Disruption ($M)	18.70	(through Operations, Maintenance, & Replacement)






Enter Schedule Lag Information - Design Build
Enter appropriate "lag" values that add constraints to successor or dependent activities.
?
Time -->
PLANNING
SCOPING
1
ENVIRONMENTAL PROCESS/ PRELIMINARY DESIGN
ENVIRONMENTAL PERMITS
C 0
0 A
0 B
3
PROCUREMENT
FINAL DESIGN
G 1
H 6
CONSTRUCTION
4
OPERATION
5
REPLACEMENT
D 0
6 K
2
E 0
0 J
I 10
ROW, UTILITY, RAILROAD
F 6
NOTE
1 = Design Funding Date
2 = ROW/UTL/ RR Funding Date
3 = Construction Funding
4 = Construction Completion Date
5 = Replacement Start Date
Back to Schedule
Save & Continue
Save & Close


Enter Project Cost Information
Enter all required cost information in the boxes below.
?
Project Phase
Base Cost (CY $M)
Planning
Scoping
Prelim Design/ Environmental Process 1.19
Environmental Permits
ROW/Util/RR 3
Procurement
Final Design
Construction 11.85
TOTAL 16.04
Cost Inflation Rate (percent/year)
Preconstruction 3
ROW/Utility/RR 3
Construction 3
Overhead Rate (CY $M/month)
Preconstruction 0.1
Construction 0.225
Back to Lag
Save & Continue
Save & Close



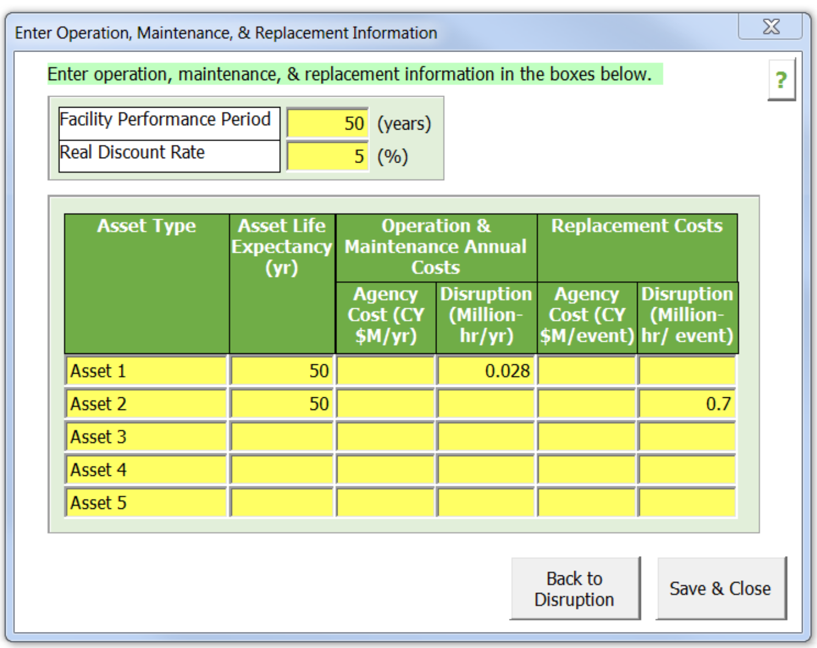
Enter Disruption Information

Enter disruption information in the boxes below.

Disruption Value	10	($M/M-hr)
Agency/User Cost Discount Factor	1	

Project Phase	Disruption (M veh-hours/day)	No. of Days
Planning		
Scoping		
Prelim Design/ Environmental Process		
Environmental Permits		
ROW/Util/RR	0.02	10
Procurement		
Final Design		
Construction	0.05	10
Operations & Maintenance		
Replacement		

Back to Cost | Save & Continue | Save & Close



Enter Operation, Maintenance, & Replacement Information

Enter operation, maintenance, & replacement information in the boxes below.

Facility Performance Period	50	(years)
Real Discount Rate	5	(%)

Asset Type	Asset Life Expectancy (yr)	Operation & Maintenance Annual Costs		Replacement Costs	
		Agency Cost (CY $M/yr)	Disruption (Million-hr/yr)	Agency Cost (CY $M/event)	Disruption (Million-hr/ event)
Asset 1	50		0.028		
Asset 2	50				0.7
Asset 3					
Asset 4					
Asset 5					

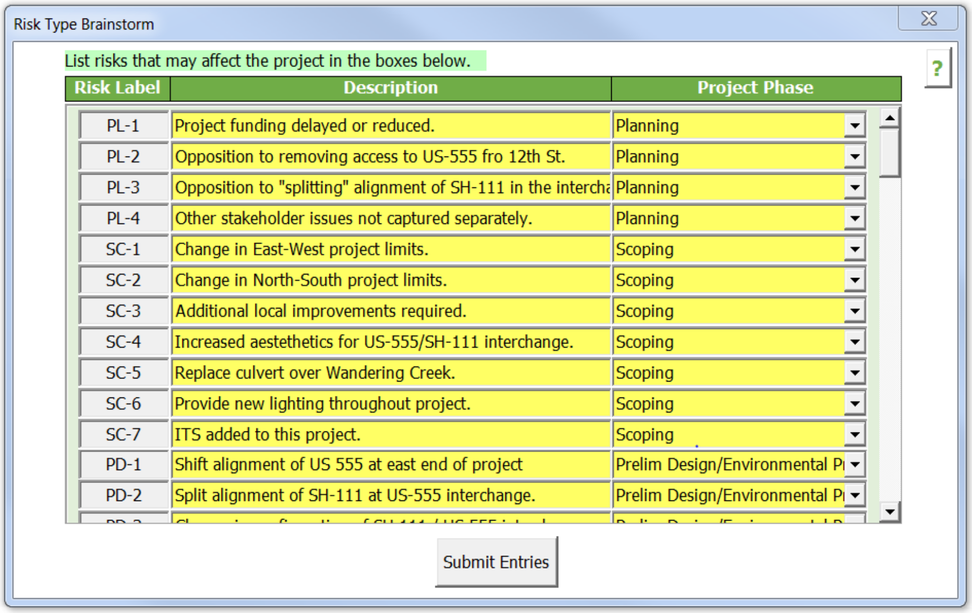
Back to Disruption | Save & Close

SHRP2 Risk Management Template

HELP Step 02 - Risk Identification

Create List of Risks | **Clear All** | <=BACK | HOME | FWD=>

Risk Label	Description of Risk Table Below Fills by Selecting "Create List of Risks" Button Above	Project Phase	Retire Risk?
PL-1	Project funding delayed or reduced.	Planning	No
PL-2	Opposition to removing access to US-555 fro 12th St.	Planning	No
PL-3	Opposition to "splitting" alignment of SH-111 in the interchange area.	Planning	No
PL-4	Other stakeholder issues not captured separately.	Planning	No
SC-1	Change in East-West project limits.	Scoping	No
SC-2	Change in North-South project limits.	Scoping	No
SC-3	Additional local improvements required.	Scoping	No
SC-4	Increased aestethetics for US-555/SH-111 interchange.	Scoping	No
SC-5	Replace culvert over Wandering Creek.	Scoping	No
SC-6	Provide new lighting throughout project.	Scoping	No
SC-7	ITS added to this project.	Scoping	No
PD-1	Shift alignment of US 555 at east end of project	Prelim Design/Environmental Process	No
PD-2	Split alignment of SH-111 at US-555 interchange.	Prelim Design/Environmental Process	No
PD-3	Change in configuration of SH 111 / US 555 interchange.	Prelim Design/Environmental Process	No
PD-4	Ground improvement required in interchange area.	Prelim Design/Environmental Process	No
PD-5	Shoulders required on US-555.	Prelim Design/Environmental Process	No
PD-6	Shoulders required on SH-111.	Prelim Design/Environmental Process	No
PD-7	Additional cost for signalized intersections.	Prelim Design/Environmental Process	No
PD-8	Change in pavement section and/or type.	Prelim Design/Environmental Process	No
PD-9	Rehabilitate instead of reconstruct existing roadway (e.g., overlay instead).	Prelim Design/Environmental Process	No
PD-10	Change in stormwater design standards.	Prelim Design/Environmental Process	No
PD-11	Cannot use City sewer system for project runoff (or City charges for use).	Prelim Design/Environmental Process	No
PD-12	Structures impacted by Main Street realignment are eligible for Historic Register.	Prelim Design/Environmental Process	No
PD-13	Change in environmental documentation.	Prelim Design/Environmental Process	No
PD-14	Delays completing environmental documentation.	Prelim Design/Environmental Process	No
PD-15	Encounter unanticipated contamination in interchange area.	Prelim Design/Environmental Process	No
PD-16	Additional wetland mitigation required for planned alignment.	Prelim Design/Environmental Process	No
EP-1	Challenge to environmental determination or permits	Environmental Permits	No
EP-2	Delay obtaining the 404 permit	Environmental Permits	No
RR-1	Uncertainty in ROW inflation rate	ROW/Util/RR	No
RR-2	Accelerating pace of development in interchange area	ROW/Util/RR	No
RR-3	Unwilling sellers	ROW/Util/RR	No
RR-4	Additional relocation or demolition required	ROW/Util/RR	No
RR-5	Additional ROW required for planned project	ROW/Util/RR	No
RR-6	Other delays to ROW planning	ROW/Util/RR	No
RR-7	Telecom utility wants a cost-sharing agreement	ROW/Util/RR	No
RR-8	QDOT helps City pay for water and sewer-line relocation	ROW/Util/RR	No
RR-9	Other utility relocations not completed on time	ROW/Util/RR	No
RR-10	Damage existing utility or encounter unanticipated utility during construction	ROW/Util/RR	No
PR-1	Uncertainty in construction-cost inflation rate	Procurement	No
PR-2	Uncertain Design/Build contracting market conditions at time of bid	Procurement	No
PR-3	Material-supply issues	Procurement	No
PR-4	Change in project delivery method	Procurement	No
PR-5	Accelerate pre-construction activities to reach NTP sooner	Procurement	No
PR-6	Use incentives to accelerate D/B construction	Procurement	No
PR-7	Issues with D/B design or submittals	Procurement	No
PR-8	Other problems with D/B contract procurement	Procurement	No
CR-1	D/B construction phasing significantly different than assumed	Construction	No
CR-2	Additional Maintenance of Traffic required	Construction	No
CR-3	Problems with planned accelerated bridge construction (ABC) technique	Construction	No
CR-4	Unable to construct interchange embankments as rapidly as assumed	Construction	No
CR-5	Difficult foundation installation	Construction	No
CR-6	Severe weather event significantly impacts construction	Construction	No
CR-7	Colder-than-usual winter	Construction	No
CR-8	Significant accident during construction	Construction	No
CR-9	Limited construction staging area in vicinity of interchange	Construction	No
CR-10	Fish window in Wandering Creek	Construction	No
CR-11	Non-compliance with permits during construction	Construction	No
CR-12	Extended overheads as a function of project delays	Construction	No


Risk Type Brainstorm
List risks that may affect the project in the boxes below.
?
Risk Label
Description
Project Phase
PL-1
Project funding delayed or reduced.
Planning
PL-2
Opposition to removing access to US-555 fro 12th St.
Planning
PL-3
Opposition to "splitting" alignment of SH-111 in the intercha
Planning
PL-4
Other stakeholder issues not captured separately.
Planning
SC-1
Change in East-West project limits.
Scoping
SC-2
Change in North-South project limits.
Scoping
SC-3
Additional local improvements required.
Scoping
SC-4
Increased aestethetics for US-555/SH-111 interchange.
Scoping
SC-5
Replace culvert over Wandering Creek.
Scoping
SC-6
Provide new lighting throughout project.
Scoping
SC-7
ITS added to this project.
Scoping
PD-1
Shift alignment of US 555 at east end of project
Prelim Design/Environmental Pr
PD-2
Split alignment of SH-111 at US-555 interchange.
Prelim Design/Environmental Pr
Submit Entries

SHRP2 Risk Management Template

HELP — Step 03 - Rating Scale

Create Rating Scale | Clear All | <=== BACK | HOME | FWD ===>

Base Cost through Construction	16.04	(CY $M)
Base Schedule	35	Months
Base Disruption through Construction	0.70	M-Hr

Data Entry Type	Absolute

COST CHANGE

Adjectival Rating	Percent of Base Cost		Absolute Value (CY $M)		Expected Mean Value	
	Low	High	Low	High	Percent	Absolute
VH	24.94	49.88	4.00	8.00	37.41	6.00
H	9.98	24.94	1.60	4.00	17.46	2.80
M	3.12	9.98	0.50	1.60	6.55	1.05
L	1.25	3.12	0.20	0.50	2.18	0.35
VL	0.00	1.25	0.00	0.20	0.62	0.10

DURATION CHANGE

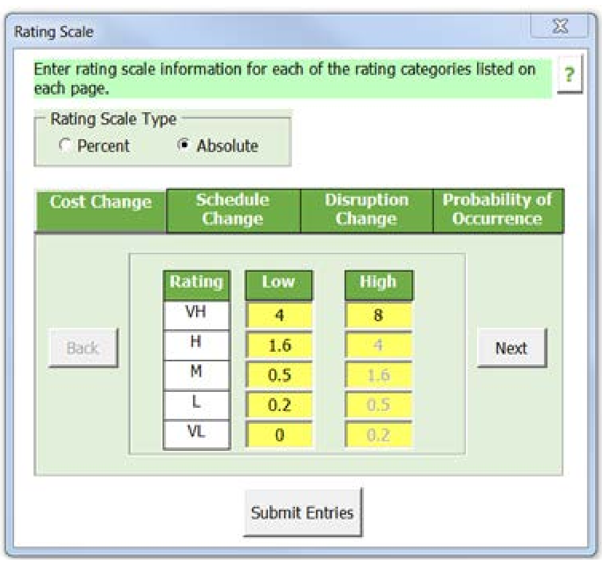
Adjectival Rating	Percent of Base Schedule		Absolute Value (months)		Expected Mean Value	
	Low	High	Low	High	Percent	Absolute
VH	34.29	68.57	12.00	24.00	51.43	18.00
H	11.43	34.29	4.00	12.00	22.86	8.00
M	2.86	11.43	1.00	4.00	7.14	2.50
L	0.71	2.86	0.25	1.00	1.79	0.63
VL	0.00	0.71	0.00	0.25	0.36	0.13

DISRUPTION CHANGE

Adjectival Rating	Percent of Base Disruption		Absolute Value (M person-Hrs)		Expected Mean Value	
	Low	High	Low	High	Percent	Absolute
VH	28.57	57.14	0.20	0.40	42.86	0.30
H	14.29	28.57	0.10	0.20	21.43	0.15
M	0.00	14.29	0.00	0.10	7.14	0.05
L	0.00	0.00	0.00	0.00	0.00	0.00
VL	0.00	0.00	0.00	0.00	0.00	0.00

PROBABILITY OF OCCURRENCE

Adjectival Rating	Probability Range		Mean Probability
	Low	High	
VH	0.70	1.00	0.85
H	0.40	0.70	0.55
M	0.20	0.40	0.30
L	0.05	0.20	0.13
VL	0.00	0.05	0.03

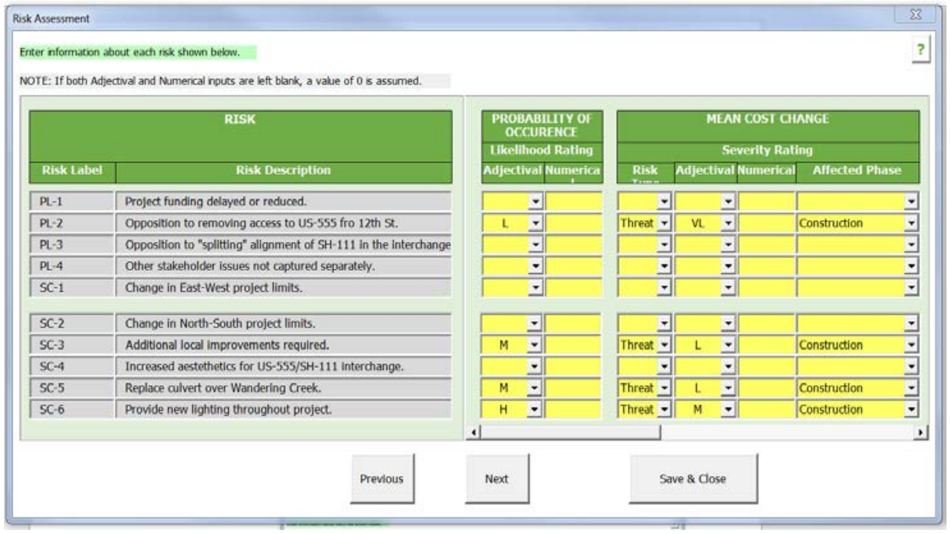


SHRP2 Risk Management Template

HELP — Step 04 - Unmitigated Risk Assessment

Conduct Risk Assessment | Calculate Mean Severity Values | **Clear All** | <=== BACK | HOME | FWD===>

Risk Label	Risk Description	Probability of Occurrence: Adjectival	Probability of Occurrence: Numerical	Probability of Occurrence: Mean Value	Mean Cost Change (CY $M): Risk Type	Mean Cost Change (CY $M): Adjectival	Mean Cost Change (CY $M): Numerical	Mean Cost Change (CY $M): Mean Value	Mean Cost Change (CY $M): Affected Phase	Mean Duration Change (months): Risk Type	Mean Duration Change (months): Adjectival	Mean Duration Change (months): Numerical	Mean Duration Change (months): Mean Value	Mean Duration Change (months): Affected Phase	Mean Disruption Change (M-Hr): Risk Type	Mean Disruption Change (M-Hr): Adjectival	Mean Disruption Change (M-Hr): Numerical	Mean Disruption Change (M-Hr): Mean Value	Mean Disruption Change (M-Hr): Affected Phase
PL-1	Project funding delayed or reduced.			0.00				0.00					0.00					0.00	
PL-2	Opposition to removing access to US-555 fro 12th St.	L		0.13	Threat	VL		0.10	Construction			0.00	0.00				0.00	0.00	
PL-3	Opposition to "splitting" alignment of SH-111 in the interchange area.			0.00				0.00					0.00					0.00	
PL-4	Other stakeholder issues not captured separately.			0.00				0.00					0.00					0.00	
SC-1	Change in East-West project limits.			0.00				0.00					0.00					0.00	
SC-2	Change in North-South project limits.			0.00				0.00					0.00					0.00	
SC-3	Additional local improvements required.	M		0.30	Threat	L		0.35	Construction	Threat	L		0.63	Prelim Design/Environmental Process			0.00	0.00	
SC-4	Increased aestethetics for US-555/SH-111 interchange.			0.00				0.00					0.00					0.00	
SC-5	Replace culvert over Wandering Creek.	M		0.30	Threat	L		0.35	Construction			0.00	0.00				0.00	0.00	
SC-6	Provide new lighting throughout project.	H		0.55	Threat	M		1.05	Construction			0.00	0.00				0.00	0.00	
SC-7	ITS added to this project.			0.00				0.00					0.00					0.00	
PD-1	Shift alignment of US 555 at east end of project	VL		0.03	Threat	M		1.05	ROW/Util/RR	Threat	M		2.50	ROW/Util/RR			0.00	0.00	
PD-2	Split alignment of SH-111 at US-555 interchange.			0.00				0.00					0.00					0.00	
PD-3	Change in configuration of SH 111 / US 555 interchange.		0.00	0.00			0.00	0.00				0.00	0.00				0.00	0.00	
PD-4	Ground improvement required in interchange area.	L		0.13	Threat	M		1.05	Construction	Threat	L		0.63	Construction			0.00	0.00	
PD-5	Shoulders required on US-555.	VL		0.03	Threat	H		2.80	Construction	Threat	M		2.50	Construction			0.00	0.00	
PD-6	Shoulders required on SH-111.	VL		0.03	Threat	H		2.80	Construction	Threat	M		2.50	Construction			0.00	0.00	
PD-7	Additional cost for signalized intersections.			0.00				0.00					0.00					0.00	
PD-8	Change in pavement section and/or type.	M		0.30	Opportunity	M		-1.05	Construction			0.00	0.00				0.00	0.00	
PD-9	Rehabilitate instead of reconstruct existing roadway (e.g., overlay instead).			0.00				0.00					0.00					0.00	
PD-10	Change in stormwater design standards.			0.00				0.00					0.00					0.00	
PD-11	Cannot use City sewer system for project runoff (or City charges for use).	M		0.30	Threat	M		1.05	ROW/Util/RR	Threat	L		0.63	ROW/Util/RR			0.00	0.00	
PD-12	Structures impacted by Main Street realignment are eligible for Historic Register.	L		0.13	Threat	M		1.05	ROW/Util/RR	Threat	M		2.50	ROW/Util/RR			0.00	0.00	
PD-13	Change in environmental documentation.	L		0.13	Threat	M		1.05	Prelim Design/Environme	Threat	H		8.00	Prelim Design/Environmental Process			0.00	0.00	
PD-14	Delays completing environmental documentation.	M		0.30				0.00		Threat	M		2.50	Prelim Design/Environmental Process			0.00	0.00	
PD-15	Encounter unanticipated contamination in interchange area.	M		0.30	Threat	VL		0.10	Construction			0.00	0.00				0.00	0.00	
PD-16	Additional wetland mitigation required for planned alignment.	M		0.30	Threat	L		0.35	Construction			0.00	0.00				0.00	0.00	
EP-1	Challenge to environmental determination or permits			0.00				0.00					0.00					0.00	
EP-2	Delay obtaining the 404 permit	L		0.13				0.00		Threat	M		2.50	Environmental Permits			0.00	0.00	
RR-1	Uncertainty in ROW inflation rate	H		0.55	Threat	M		1.05	ROW/Util/RR			0.00	0.00				0.00	0.00	
RR-2	Accelerating pace of development in interchange area	M		0.30	Threat	M		1.05	ROW/Util/RR	Threat	M		2.50	ROW/Util/RR			0.00	0.00	
RR-3	Unwilling sellers	H		0.55	Threat	M		1.05	ROW/Util/RR			0.00	0.00				0.00	0.00	
RR-4	Additional relocation or demolition required			0.00				0.00					0.00					0.00	
RR-5	Additional ROW required for planned project			0.00				0.00					0.00					0.00	
RR-6	Other delays to ROW planning	M		0.30				0.00		Threat	L		0.63	ROW/Util/RR			0.00	0.00	
RR-7	Telecom utility wants a cost-sharing agreement	M		0.30	Threat	L		0.35	ROW/Util/RR			0.00	0.00				0.00	0.00	
RR-8	QDOT helps City pay for water and sewer-line relocation	H		0.55	Threat	M		1.05	ROW/Util/RR			0.00	0.00				0.00	0.00	
RR-9	Other utility relocations not completed on time			0.00				0.00					0.00					0.00	
RR-10	Damage existing utility or encounter unanticipated utility during construction			0.00				0.00					0.00					0.00	
PR-1	Uncertainty in construction-cost inflation rate	H		0.55	Threat	M		1.05	Construction			0.00	0.00				0.00	0.00	
PR-2	Uncertain Design/Build contracting market conditions at time of bid		0.25	0.25	Threat		1.19	1.19	Construction	Threat		1.00	1.00	Procurement			0.00	0.00	
PR-3	Material-supply issues			0.00				0.00					0.00					0.00	
PR-4	Change in project delivery method			0.00				0.00					0.00					0.00	
PR-5	Accelerate pre-construction activities to reach NTP sooner			0.00				0.00					0.00					0.00	
PR-6	Use incentives to accelerate D/B construction			0.00				0.00					0.00					0.00	
PR-7	Issues with D/B design or submittals	M		0.30				0.00		Threat	M		2.50	Final Design			0.00	0.00	
PR-8	Other problems with D/B contract procurement	L		0.13				0.00		Threat	L		0.63	Procurement			0.00	0.00	
CR-1	D/B construction phasing significantly different than assumed		0.25	0.25				0.00		Opportunity		2.00	-2.00	Construction	Opportunity		0.10	-0.10	Construction
CR-2	Additional Maintenance of Traffic required	H		0.55	Threat	L		0.35	Construction	Threat	VL		0.13	Construction	Threat	M		0.05	Construction
CR-3	Problems with planned accelerated bridge construction (ABC) technique	H		0.55	Threat	L		0.35	Construction	Threat	L		0.63	Construction	Threat	L		0.00	Construction
CR-4	Unable to construct interchange embankments as rapidly as assumed	M		0.30	Threat	L		0.35	Construction	Threat	M		2.50	Construction		L		0.00	Construction
CR-5	Difficult foundation installation	L		0.13	Threat	L		0.35	Construction	Threat	L		0.63	Construction	Threat	VL		0.00	Construction
CR-6	Severe weather event significantly impacts construction			0.00				0.00					0.00					0.00	
CR-7	Colder-than-usual winter	L		0.13				0.00		Threat	VL		0.13	Construction	Threat	VL		0.00	Construction
CR-8	Significant accident during construction			0.00				0.00					0.00					0.00	
CR-9	Limited construction staging area in vicinity of interchange	M		0.30	Threat	VL		0.10	Construction			0.00	0.00				0.00	0.00	
CR-10	Fish window in Wandering Creek			0.00				0.00					0.00					0.00	
CR-11	Non-compliance with permits during construction			0.00				0.00					0.00					0.00	
CR-12	Extended overheads as a function of project delays			0.00				0.00					0.00					0.00	



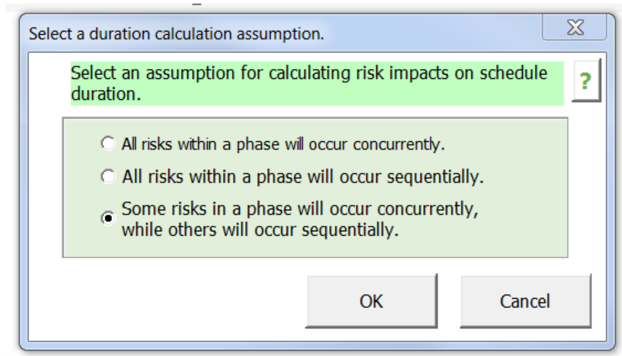
SHRP2 Risk Management Template

HELP **Step 05 - Unmitigated Risk Register**

NOTE: Risks and opportunities are sorted by total severity, though the order should be identical whether using raw severity or percent of total severity

<=== BACK | HOME | FWD ===>

Risk Label	Risk Description	Risk Type	Mean Cost Impact (CY $M)	Mean Duration Impact (months)	Mean Disruption Impact (M-Hr)	Mean Change to Critical Path Schedule	Mean Severity (YOE $M)	Percent of Total Severity	Risk Ranking based on Mean Severity	Select Risk for Mitigation
SC-6	Provide new lighting throughout project.	Threat	0.58	0.00	0.00	0.00	0.62	8.21%	1	Yes
PR-1	Uncertainty in construction-cost inflation rate	Threat	0.58	0.00	0.00	0.00	0.62	8.21%	2	Yes
RR-1	Uncertainty in ROW inflation rate	Threat	0.58	0.00	0.00	0.00	0.60	8.03%	3	No
RR-3	Unwilling sellers	Threat	0.58	0.00	0.00	0.00	0.60	8.03%	4	Yes
RR-8	QDOT helps City pay for water and sewer-line relocation	Threat	0.58	0.00	0.00	0.00	0.60	8.03%	5	Yes
RR-2	Accelerating pace of development in interchange area	Threat	0.32	0.75	0.00	0.75	0.51	6.82%	6	Yes
CR-2	Additional Maintenance of Traffic required	Threat	0.19	0.07	0.03	0.07	0.51	6.74%	7	Yes
CR-4	Unable to construct interchange embankments as rapidly as assumed	Threat	0.11	0.75	0.00	0.75	0.39	5.21%	8	Yes
PD-13	Change in environmental documentation.	Threat	0.13	1.00	0.00	1.00	0.38	5.05%	9	No
PR-2	Uncertain Design/Build contracting market conditions at time of bid	Threat	0.30	0.25	0.00	0.25	0.38	5.00%	10	No
PD-11	Cannot use City sewer system for project runoff (or City charges for use).	Threat	0.32	0.19	0.00	0.19	0.37	4.99%	11	Yes
CR-3	Problems with planned accelerated bridge construction (ABC) technique	Threat	0.19	0.34	0.00	0.34	0.33	4.44%	12	Yes
PD-12	Structures impacted by Main Street realignment are eligible for Historic Register.	Threat	0.13	0.31	0.00	0.31	0.21	2.84%	13	No
PD-14	Delays completing environmental documentation.	Threat	0.00	0.75	0.00	0.75	0.18	2.45%	14	Yes
PD-4	Ground improvement required in interchange area.	Threat	0.13	0.08	0.00	0.08	0.17	2.25%	15	No
SC-3	Additional local improvements required.	Threat	0.11	0.19	0.00	0.19	0.16	2.11%	16	No
SC-5	Replace culvert over Wandering Creek.	Threat	0.11	0.00	0.00	0.00	0.11	1.49%	17	No
PD-16	Additional wetland mitigation required for planned alignment.	Threat	0.11	0.00	0.00	0.00	0.11	1.49%	18	No
RR-7	Telecom utility wants a cost-sharing agreement	Threat	0.11	0.00	0.00	0.00	0.11	1.46%	19	No
PD-5	Shoulders required on US-555.	Threat	0.07	0.06	0.00	0.06	0.10	1.31%	20	No
PD-6	Shoulders required on SH-111.	Threat	0.07	0.06	0.00	0.06	0.10	1.31%	21	No
CR-5	Difficult foundation installation	Threat	0.04	0.08	0.00	0.08	0.08	1.01%	22	No
EP-2	Delay obtaining the 404 permit	Threat	0.00	0.31	0.00	0.31	0.07	0.98%	23	No
RR-6	Other delays to ROW planning	Threat	0.00	0.19	0.00	0.19	0.05	0.61%	24	No
PD-1	Shift alignment of US 555 at east end of project	Threat	0.03	0.06	0.00	0.06	0.04	0.57%	25	No
PD-15	Encounter unanticipated contamination in interchange area.	Threat	0.03	0.00	0.00	0.00	0.03	0.43%	26	No
CR-9	Limited construction staging area in vicinity of interchange	Threat	0.03	0.00	0.00	0.00	0.03	0.43%	27	No
PR-8	Other problems with D/B contract procurement	Threat	0.00	0.08	0.00	0.08	0.02	0.24%	28	No
PL-2	Opposition to removing access to US-555 fro 12th St.	Threat	0.01	0.00	0.00	0.00	0.01	0.18%	29	No
CR-7	Colder-than-usual winter	Threat	0.00	0.02	0.00	0.02	0.01	0.08%	30	No
CR-1	D/B construction phasing significantly different than assumed	Opportunity	0.00	-0.50	-0.03	-0.50	-0.44	56.41%	1	No
PD-8	Change in pavement section and/or type.	Opportunity	-0.32	0.00	0.00	0.00	-0.34	43.59%	2	No
PL-1	Project funding delayed or reduced.	No Impact	0.00	0.00	0.00	0.00	0.00	0.00%		No
PL-3	Opposition to "splitting" alignment of SH-111 in the interchange area.	No Impact	0.00	0.00	0.00	0.00	0.00	0.00%		No
PL-4	Other stakeholder issues not captured separately.	No Impact	0.00	0.00	0.00	0.00	0.00	0.00%		No
SC-1	Change in East-West project limits.	No Impact	0.00	0.00	0.00	0.00	0.00	0.00%		No
SC-2	Change in North-South project limits.	No Impact	0.00	0.00	0.00	0.00	0.00	0.00%		No
SC-4	Increased aestethetics for US-555/SH-111 interchange.	No Impact	0.00	0.00	0.00	0.00	0.00	0.00%		No
SC-7	ITS added to this project.	No Impact	0.00	0.00	0.00	0.00	0.00	0.00%		No
PD-2	Split alignment of SH-111 at US-555 interchange.	No Impact	0.00	0.00	0.00	0.00	0.00	0.00%		No
PD-3	Change in configuration of SH 111 / US 555 interchange.	No Impact	0.00	0.00	0.00	0.00	0.00	0.00%		No
PD-7	Additional cost for signalized intersections.	No Impact	0.00	0.00	0.00	0.00	0.00	0.00%		No
PD-9	Rehabilitate instead of reconstruct existing roadway (e.g., overlay instead).	No Impact	0.00	0.00	0.00	0.00	0.00	0.00%		No
PD-10	Change in stormwater design standards.	No Impact	0.00	0.00	0.00	0.00	0.00	0.00%		No
EP-1	Challenge to environmental determination or permits	No Impact	0.00	0.00	0.00	0.00	0.00	0.00%		No
RR-4	Additional relocation or demolition required	No Impact	0.00	0.00	0.00	0.00	0.00	0.00%		No
RR-5	Additional ROW required for planned project	No Impact	0.00	0.00	0.00	0.00	0.00	0.00%		No
RR-9	Other utility relocations not completed on time	No Impact	0.00	0.00	0.00	0.00	0.00	0.00%		No
RR-10	Damage existing utility or encounter unanticipated utility during construction	No Impact	0.00	0.00	0.00	0.00	0.00	0.00%		No
PR-3	Material-supply issues	No Impact	0.00	0.00	0.00	0.00	0.00	0.00%		No
PR-4	Change in project delivery method	No Impact	0.00	0.00	0.00	0.00	0.00	0.00%		No
PR-5	Accelerate pre-construction activities to reach NTP sooner	No Impact	0.00	0.00	0.00	0.00	0.00	0.00%		No
PR-6	Use incentives to accelerate D/B construction	No Impact	0.00	0.00	0.00	0.00	0.00	0.00%		No
PR-7	Issues with D/B design or submittals	No Impact	0.00	0.75	0.00	0.00	0.00	0.00%		No
CR-6	Severe weather event significantly impacts construction	No Impact	0.00	0.00	0.00	0.00	0.00	0.00%		No
CR-8	Significant accident during construction	No Impact	0.00	0.00	0.00	0.00	0.00	0.00%		No
CR-10	Fish window in Wandering Creek	No Impact	0.00	0.00	0.00	0.00	0.00	0.00%		No
CR-11	Non-compliance with permits during construction	No Impact	0.00	0.00	0.00	0.00	0.00	0.00%		No
CR-12	Extended overheads as a function of project delays	No Impact	0.00	0.00	0.00	0.00	0.00	0.00%		No



SHRP2 Risk Management Template

HELP

Step 06 - Unmitigated Project Performance

Schedule Duration Assumption:
Some risks in a phase will occur concurrently, while others will occur sequentially.

Create Risk Analysis Summary

<==BACK

HOME

FWD==>

Unmitigated Project Cost, Duration, and Disruption Performance

Project Phase	Base			Risk			Total (Base + Risk)			
	Cost (CY $M)	Duration (months)	Disruption (M-hrs)	Cost (CY $M)	Duration (months)	Disruption (M-hrs)	Cost (CY $M)	Duration (months)	Disruption (M-hrs)	Cost (YOE $M)
Planning		0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Scoping		0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Prelim Design/Environmental Process	1.19	12	0.00	0.13	1.47	0.00	1.32	13.47	0.00	1.34
Environmental Permits		6	0.00	0.00	0.31	0.00	0.00	6.31	0.00	0.00
ROW/Util/RR	3.00	12	0.20	2.63	1.13	0.00	5.63	13.13	0.20	5.91
Final Design		6	0.00	0.00	0.75	0.00	0.00	6.75	0.00	0.00
Procurement		6	0.00	0.26	0.29	0.00	0.26	6.29	0.00	0.27
Construction	11.85	16	0.50	2.52	0.85	0.00	14.37	16.85	0.50	15.47
Operations & Maintenance	0.00	600	1.40	0.00	0.00	0.00	0.00	600.00	1.40	0.00
Replacement	0.00	0	0.70	0.00		0.00	0.00	0.00	0.70	
Total	**16.04**		**2.80**	**5.54**		**0.00**	**21.58**		**2.80**	**23.00**

Project Schedule Performance (Base vs. Unmitigated)

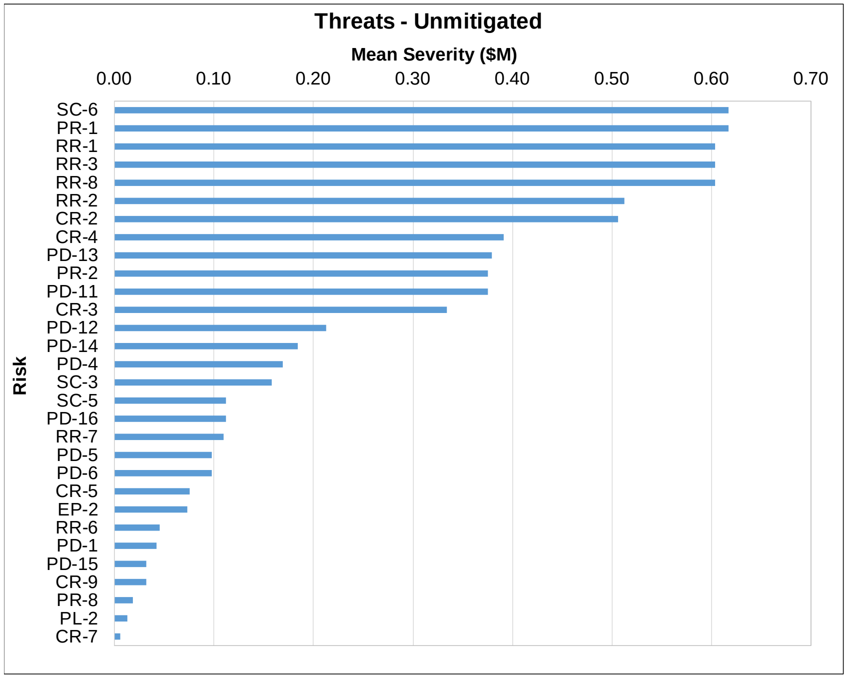
Project Phase	Base Project Schedule Performance						Unmitigated Project Schedule Performance						Mean Severity YOE ($M)
	Duration (Months/Date)	Early Start	Early Finish	Late Start	Late Finish	Float (months)	Duration (Months / Date)	Early Start	Early Finish	Late Start	Late Finish	Float (months)	
Planning	0.00	12/1/2009	12/1/2009	12/1/2009	12/1/2009	0.00	0.00	12/1/2009	12/1/2009	12/1/2009	12/1/2009	0.00	0.01
Scoping	0.00	12/1/2009	12/1/2009	12/1/2009	12/1/2009	0.00	0.00	12/1/2009	12/1/2009	12/1/2009	12/1/2009	0.00	0.89
Design Funding Date	12/1/2009		12/1/2009		12/1/2009	0.00	12/1/2009		12/1/2009		12/1/2009	0.00	0.00
Prelim Design/Environmental Process	12.00	12/1/2009	11/30/2010	12/1/2009	11/30/2010	0.00	13.47	12/1/2009	1/14/2011	12/1/2009	1/14/2011	0.00	1.37
Environmental Permits	6.00	11/30/2010	6/1/2011	11/30/2010	6/1/2011	0.00	6.31	1/14/2011	7/25/2011	2/8/2011	8/19/2011	0.81	0.07
ROW/Util/RR Funding Date	12/1/2009		12/1/2009		11/30/2011	24.00	12/1/2009		12/1/2009		2/17/2012	26.59	0.00
ROW/Util/RR	12.00	11/30/2010	11/30/2011	11/30/2010	11/30/2011	0.00	13.13	1/14/2011	2/17/2012	1/14/2011	2/17/2012	0.00	2.48
Construction Funding Date	12/1/2009		12/1/2009		11/30/2010	12.00	12/1/2009		12/1/2009		2/8/2011	14.30	0.00
Procurement	6.00	11/30/2010	6/1/2011	11/30/2010	6/1/2011	0.00	6.29	1/14/2011	8/19/2011	2/8/2011	8/19/2011	0.00	1.01
Final Design	6.00	6/1/2011	11/30/2011	6/1/2011	4/30/2012	5.00	6.75	8/19/2011	3/11/2012	8/19/2011	8/13/2012	5.10	0.00
Construction	16.00	7/1/2011	10/30/2012	7/1/2011	10/30/2012	0.00	16.85	9/18/2011	2/11/2013	9/18/2011	2/11/2013	0.00	0.91
Operations & Maintenance	600.00	10/30/2012	10/8/2062	10/30/2012	10/8/2062		600.00	2/11/2013	1/20/2063	2/11/2013	1/20/2063		
Replacement	0.00	10/8/2062	10/8/2062	10/8/2062	10/8/2062		0.00	1/20/2063	1/20/2063	1/20/2063	1/20/2063		
Project Start Date	**12/1/2009**						**12/1/2009**					**Total**	6.74
Construction Finish Date	**10/30/2012**						**2/11/2013**						
Project Duration (months)	**35.00**						**38.45**						

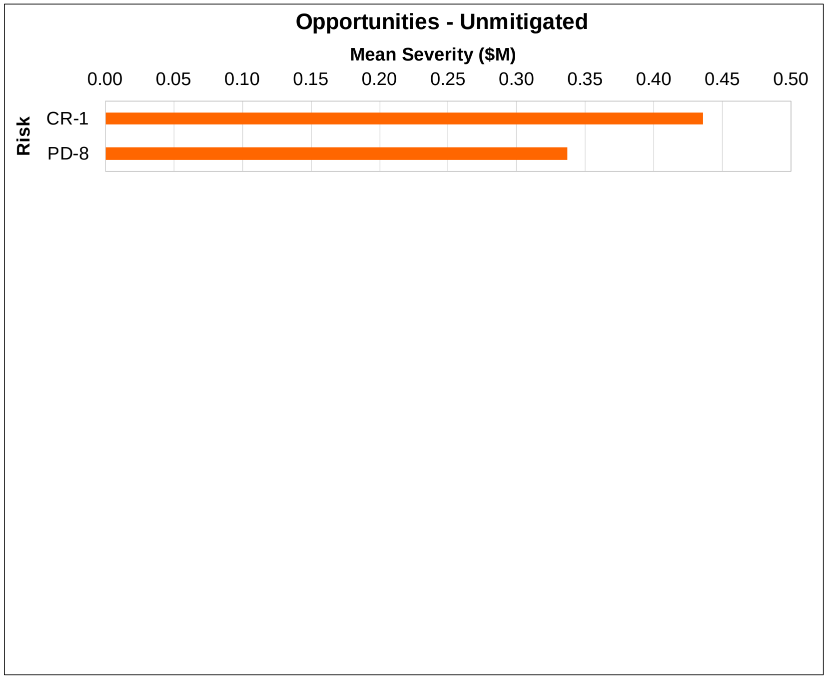
SHRP2 Risk Management Template

HELP

Step 07 - Unmitigated Risk Ranking Plots

<==BACK HOME FWD==>





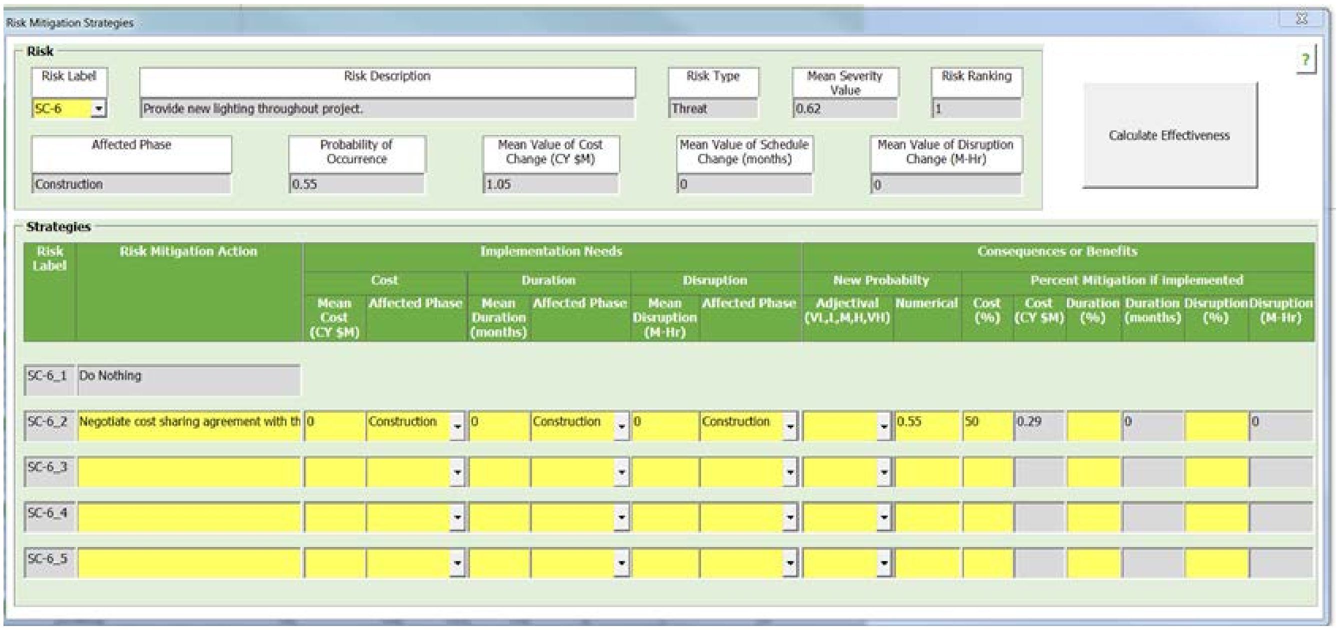
SHRP2 Risk Management Template

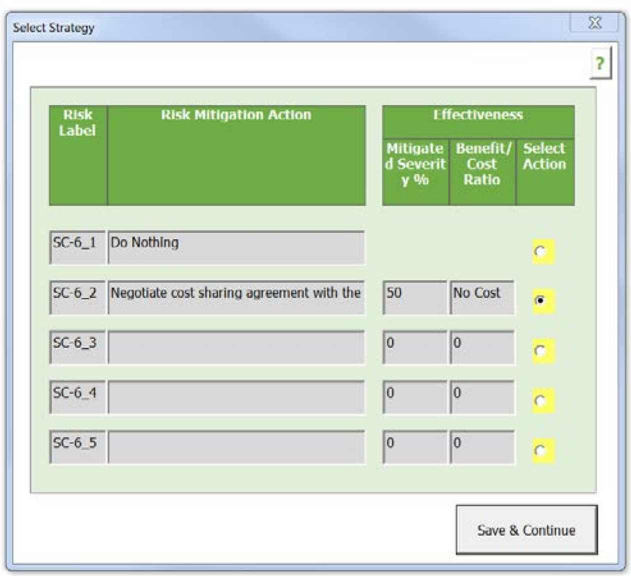
HELP

Step 08 - Risk Mitigation Strategies

Conduct Risk Mitigation | Create Registers | Clear All | <===BACK | HOME | FWD==>

Risk Mitigation Label	Risk Mitigation Actions	Implementation Needs of Risk Mitigation Actions						Consequences of Risk Mitigation Actions										Effectiveness of Risk Mitigation Actions		
		Cost		Schedule		Disruption		New Probability		Percentage Mitigated, if implemented								
		Mean Cost (CY $M)	Affected Phase	Mean Duration (months)	Affected Phase	Mean Disruption (M-Hr)	Affected Phase	Adjectival (VL, L, M, H, VH)	Numerical	Cost (%)	Mean Cost (CY $M)	Duration (%)	Mean Duration (months)	Disruption (%)	Mean Disruption (M-Hr)	Mitigated Severity (%)	Benefit/Cost Ratio	Action Selected
SC-6	Provide new lighting throughout project.																	
SC-6_1	Do Nothing								0.55	0.00	1.05	0.00	0	0.00	0			No
SC-6_2	Negotiate cost sharing agreement with the city	0.00	Construction	0.00	Construction	0.00	Construction		0.55	50.00	0.29		0.00		0.00	50.00	No Cost	Yes
SC-6_3																		No
SC-6_4																		No
SC-6_5																		No
RR-3	Unwilling sellers																	
RR-3_1	Do Nothing								0.55	0.00	1.05	0.00	0	0.00	0			No
RR-3_2	Make reasonable early offer	0.05	ROW/Util/RR	0.00	ROW/Util/RR	0.00	ROW/Util/RR		0.28		0.29		0.00		0.00	50.00	5.77	Yes
RR-3_3																		No
RR-3_4																		No
RR-3_5																		No
CR-2	Additional Maintenance of Traffic required																	
CR-2_1	Do Nothing								0.55	0.00	0.35	0.00	0.125	0.00	0.05			No
CR-2_2	Reduce traffic demand during closures	0.05	Final Design	0.00	Final Design	0.00	Construction		0.28		0.10		0.03	67.00	0.00	68.20	6.56	Yes
CR-2_3																		No
CR-2_4																		No
CR-2_5																		No
RR-2	Accelerating pace of development in interchang																	
RR-2_1	Do Nothing								0.30	0.00	1.05	0.00	2.5	0.00	0			No
RR-2_2	Coordinate with City - stop issuing permits for new develoipments	0.00	ROW/Util/RR	0.00	ROW/Util/RR	0.00	ROW/Util/RR		0.15		0.16		0.38		0.00	50.04	No Cost	Yes
RR-2_3																		No
RR-2_4																		No
RR-2_5																		No
PD-11	Cannot use City sewer system for project runof																	
PD-11_1	Do Nothing								0.30	0.00	1.05	0.00	0.625	0.00	0			No
PD-11_2	Same action as RR8 (affects RR8 and PD11)	0.00	Final Design	0.00	Final Design	0.00	Final Design		0.15		0.16		0.09		0.00	50.01	No Cost	Yes
PD-11_3																		No
PD-11_4																		No
PD-11_5																		No
RR-8	QDOT helps City pay for water and sewer-line																	
RR-8_1	Do Nothing								0.55	0.00	1.05	0.00	0	0.00	0			No
RR-8_2	Decide to help City pay for water and sewer line relocation	0.00	Construction	0.00	Construction	0.00	Construction		0.87		0.91		0.00		0.00	-57.27	No Cost	Yes
RR-8_3																		No
RR-8_4																		No
RR-8_5																		No
CR-4	Unable to construct interchange embankments a																	
CR-4_1	Do Nothing								0.30	0.00	0.35	0.00	2.5	0.00	0			No
CR-4_2	Conduct additional investigations and analysis to ddevelop alt techniques	0.10	Final Design	0.00	Final Design	0.00	Construction		0.15		0.05		0.38		0.00	50.04	1.86	Yes
CR-4_3																		No
CR-4_4																		No
CR-4_5																		No
CR-3	Problems with planned accelerated bridge const																	
CR-3_1	Do Nothing								0.55	0.00	0.35	0.00	0.625	0.00	0			No
CR-3_2	Pre-qualify contractors + require development of ABC technique	0.05	Final Design	0.00	Final Design	0.00	Construction		0.28		0.10		0.17		0.00	50.02	3.17	Yes
CR-3_3																		No
CR-3_4																		No
CR-3_5																		No


Risk Mitigation Strategies
Risk
Risk Label
SC-6
Risk Description
Provide new lighting throughout project.
Risk Type
Threat
Mean Severity Value
0.62
Risk Ranking
1
Affected Phase
Construction
Probability of Occurrence
0.55
Mean Value of Cost Change (CY $M)
1.05
Mean Value of Schedule Change (months)
0
Mean Value of Disruption Change (M-Hr)
0
Calculate Effectiveness
Strategies
Risk Label
Risk Mitigation Action
Implementation Needs
Cost
Duration
Disruption
Mean Cost (CY $M)
Affected Phase
Mean Duration (months)
Affected Phase
Mean Disruption (M-Hr)
Affected Phase
Consequences or Benefits
New Probabilty
Adjectival (VL,L,M,H,VH)
Numerical
Percent Mitigation if implemented
Cost (%)
Cost (CY $M)
Duration (%)
Duration (months)
Disruption (%)
Disruption (M-Hr)
SC-6_1
Do Nothing
SC-6_2
Negotiate cost sharing agreement with th
0
Construction
0
Construction
0
Construction
0.55
50
0.29
0
0
SC-6_3
SC-6_4
SC-6_5


Select Strategy
Risk Label
Risk Mitigation Action
Effectiveness
Mitigated Severity %
Benefit/ Cost Ratio
Select Action
SC-6_1
Do Nothing
SC-6_2
Negotiate cost sharing agreement with the
50
No Cost
SC-6_3
0
0
SC-6_4
0
0
SC-6_5
0
0
Save & Continue

SHRP2 Risk Management Template

HELP

Step 09 - Mitigation Strategies Register

NOTE: The order of the risks here is similar to the order of the risks selected for mitigation in Step 05- Unmitigated Risk Register

<===BACK HOME FWD===>

Risk Label	Risk Description	Risk Mitigation Label	Risk Mitigation Action Description	Implementation Effort					Mitigated Risk Effort					Effectiveness of Mitigation Actions				
				Mean Cost Change (YOE $M)	Mean Duration Change (YOE $M)	Mean Disruption Change (YOE $M)	Mean Change to Crit. Path (YOE $M)	Mean Severity (YOE $M)	Mean Cost Change (YOE $M)	Mean Duration Change (YOE $M)	Mean Disruption Change (YOE $M)	Mean Change to Crit. Path (YOE $M)	Mean Severity (YOE $M)	Mitigated Severity %	Benefit/Cost Ratio	Responsibility	Schedule /Milestone	Comments
SC-6	Provide new lighting throughout project.	SC-6_2	Negotiate cost sharing agreement with the city	0.00	0.00	0.00	0.00	0.00	0.29	0.00	0.00	0.00	0.31	50.00	No Cost	Project Director	Midway thru prelim design	
RR-3	Unwilling sellers	RR-3_2	Make reasonable early offer	0.05	0.00	0.00	0.00	0.05	0.29	0.00	0.00	0.00	0.30	50.00	5.77	Project Engineer	Midway thru ROW/Util/RR	
CR-2	Additional Maintenance of Traffic required	CR-2_2	Reduce traffic demand during closures	0.05	0.00	0.00	0.00	0.05	0.10	0.03	0.00	0.03	0.16	68.20	6.56	Project Engineer	Midway thru final design	
RR-2	Accelerating pace of development in interchange area	RR-2_2	Coordinate with City - stop issuing permits for new develoipments	0.00	0.00	0.00	0.00	0.00	0.16	0.38	0.00	0.37	0.26	50.04	No Cost	Project Engineer	Midway thru prelim design	
PD-11	Cannot use City sewer system for project runoff (or City charges for use).	PD-11_2	Same action as RR8 (affects RR8 and PD11)	0.00	0.00	0.00	0.00	0.00	0.16	0.09	0.00	0.09	0.19	50.01	No Cost	Project Engineer	Midway thru prelim design	
RR-8	QDOT helps City pay for water and sewer-line relocation	RR-8_2	Decide to help City pay for water and sewer line relocation	0.00	0.00	0.00	0.00	0.00	0.91	0.00	0.00	0.00	0.95	-57.27	No Cost			
CR-4	Unable to construct interchange embankments as rapidly as assumed	CR-4_2	Conduct additional investigations and analysis to ddevelop alt techniques	0.10	0.00	0.00	0.00	0.11	0.05	0.38	0.00	0.38	0.20	50.04	1.86	Project Engineer	Midway thru final design	
CR-3	Problems with planned accelerated bridge construction (ABC) technique	CR-3_2	Pre-qualify contractors + require development of ABC technique	0.05	0.00	0.00	0.00	0.05	0.10	0.17	0.00	0.17	0.17	50.02	3.17	Project Engineer	Midway thru final design	

SHRP2 Risk Management Template

HELP — Step 10 - Mitigated Risk Register

NOTE: Risks and opportunities are sorted by total severity, though the order should be identical whether using raw severity or percent of total severity

<===BACK   HOME   FWD===>

Risk Label	Risk Description	Risk Type	Mean Cost Impact (CY $M)	Mean Duration Impact (months)	Mean Disruption Impact (M-Hr)	Mean Change to Critical Path Schedule	Mean Severity (YOE $M)	Percent of Total Mean Severity	Risk Ranking based on Mean Severity	Retire Risk ?
RR-8	QDOT helps City pay for water and sewer-line relocation	Threat	0.91	0.00	0.00	0.00	0.95	0.16	1	No
PR-1	Uncertainty in construction-cost inflation rate	Threat	0.58	0.00	0.00	0.00	0.62	0.10	2	No
RR-1	Uncertainty in ROW inflation rate	Threat	0.58	0.00	0.00	0.00	0.60	0.10	3	No
PD-13	Change in environmental documentation.	Threat	0.13	1.00	0.00	1.00	0.38	0.06	4	No
PR-2	Uncertain Design/Build contracting market conditions at time of bid	Threat	0.30	0.25	0.00	0.25	0.38	0.06	5	No
SC-6	Provide new lighting throughout project.	Threat	0.29	0.00	0.00	0.00	0.31	0.05	6	No
RR-3	Unwilling sellers	Threat	0.29	0.00	0.00	0.00	0.30	0.05	7	No
RR-2	Accelerating pace of development in interchange area	Threat	0.16	0.38	0.00	0.37	0.26	0.04	8	No
PD-12	Structures impacted by Main Street realignment are eligible for Historic Register.	Threat	0.13	0.31	0.00	0.31	0.21	0.03	9	No
CR-4	Unable to construct interchange embankments as rapidly as assumed	Threat	0.05	0.38	0.00	0.38	0.20	0.03	10	No
PD-11	Cannot use City sewer system for project runoff (or City charges for use).	Threat	0.16	0.09	0.00	0.09	0.19	0.03	11	No
PD-14	Delays completing environmental documentation.	Threat	0.00	0.75	0.00	0.75	0.18	0.03	12	No
PD-4	Ground improvement required in interchange area.	Threat	0.13	0.08	0.00	0.08	0.17	0.03	13	No
CR-3	Problems with planned accelerated bridge construction (ABC) technique	Threat	0.10	0.17	0.00	0.17	0.17	0.03	14	No
CR-2	Additional Maintenance of Traffic required	Threat	0.10	0.03	0.00	0.03	0.16	0.03	15	No
SC-3	Additional local improvements required.	Threat	0.11	0.19	0.00	0.19	0.16	0.03	16	No
SC-5	Replace culvert over Wandering Creek.	Threat	0.11	0.00	0.00	0.00	0.11	0.02	17	No
PD-16	Additional wetland mitigation required for planned alignment.	Threat	0.11	0.00	0.00	0.00	0.11	0.02	18	No
RR-7	Telecom utility wants a cost-sharing agreement	Threat	0.11	0.00	0.00	0.00	0.11	0.02	19	No
PD-5	Shoulders required on US-555.	Threat	0.07	0.06	0.00	0.06	0.10	0.02	20	No
PD-6	Shoulders required on SH-111.	Threat	0.07	0.06	0.00	0.06	0.10	0.02	21	No
CR-5	Difficult foundation installation	Threat	0.04	0.08	0.00	0.08	0.08	0.01	22	No
EP-2	Delay obtaining the 404 permit	Threat	0.00	0.31	0.00	0.31	0.07	0.01	23	No
RR-6	Other delays to ROW planning	Threat	0.00	0.19	0.00	0.19	0.05	0.01	24	No
PD-1	Shift alignment of US 555 at east end of project	Threat	0.03	0.06	0.00	0.06	0.04	0.01	25	No
PD-15	Encounter unanticipated contamination in interchange area.	Threat	0.03	0.00	0.00	0.00	0.03	0.01	26	No
CR-9	Limited construction staging area in vicinity of interchange	Threat	0.03	0.00	0.00	0.00	0.03	0.01	27	No
PR-8	Other problems with D/B contract procurement	Threat	0.00	0.08	0.00	0.08	0.02	0.00	28	No
PL-2	Opposition to removing access to US-555 fro 12th St.	Threat	0.01	0.00	0.00	0.00	0.01	0.00	29	No
CR-7	Colder-than-usual winter	Threat	0.00	0.02	0.00	0.02	0.01	0.00	30	No
CR-1	D/B construction phasing significantly different than assumed	Opportunity	0.00	-0.50	-0.03	-0.50	-0.44	0.56	1	No
PD-8	Change in pavement section and/or type.	Opportunity	-0.32	0.00	0.00	0.00	-0.34	0.44	2	No
PL-1	Project funding delayed or reduced.	No Impact	0.00	0.00	0.00	0.00	0.00	0.00		No
PL-3	Opposition to "splitting" alignment of SH-111 in the interchange area.	No Impact	0.00	0.00	0.00	0.00	0.00	0.00		No
PL-4	Other stakeholder issues not captured separately.	No Impact	0.00	0.00	0.00	0.00	0.00	0.00		No
SC-1	Change in East-West project limits.	No Impact	0.00	0.00	0.00	0.00	0.00	0.00		No
SC-2	Change in North-South project limits.	No Impact	0.00	0.00	0.00	0.00	0.00	0.00		No
SC-4	Increased aestethetics for US-555/SH-111 interchange.	No Impact	0.00	0.00	0.00	0.00	0.00	0.00		No
SC-7	ITS added to this project.	No Impact	0.00	0.00	0.00	0.00	0.00	0.00		No
PD-2	Split alignment of SH-111 at US-555 interchange.	No Impact	0.00	0.00	0.00	0.00	0.00	0.00		No
PD-3	Change in configuration of SH 111 / US 555 interchange.	No Impact	0.00	0.00	0.00	0.00	0.00	0.00		No
PD-7	Additional cost for signalized intersections.	No Impact	0.00	0.00	0.00	0.00	0.00	0.00		No
PD-9	Rehabilitate instead of reconstruct existing roadway (e.g., overlay instead).	No Impact	0.00	0.00	0.00	0.00	0.00	0.00		No
PD-10	Change in stormwater design standards.	No Impact	0.00	0.00	0.00	0.00	0.00	0.00		No
EP-1	Challenge to environmental determination or permits	No Impact	0.00	0.00	0.00	0.00	0.00	0.00		No
RR-4	Additional relocation or demolition required	No Impact	0.00	0.00	0.00	0.00	0.00	0.00		No
RR-5	Additional ROW required for planned project	No Impact	0.00	0.00	0.00	0.00	0.00	0.00		No
RR-9	Other utility relocations not completed on time	No Impact	0.00	0.00	0.00	0.00	0.00	0.00		No
RR-10	Damage existing utility or encounter unanticipated utility during construction	No Impact	0.00	0.00	0.00	0.00	0.00	0.00		No
PR-3	Material-supply issues	No Impact	0.00	0.00	0.00	0.00	0.00	0.00		No
PR-4	Change in project delivery method	No Impact	0.00	0.00	0.00	0.00	0.00	0.00		No
PR-5	Accelerate pre-construction activities to reach NTP sooner	No Impact	0.00	0.00	0.00	0.00	0.00	0.00		No
PR-6	Use incentives to accelerate D/B construction	No Impact	0.00	0.00	0.00	0.00	0.00	0.00		No
PR-7	Issues with D/B design or submittals	No Impact	0.00	0.75	0.00	0.00	0.00	0.00		No
CR-6	Severe weather event significantly impacts construction	No Impact	0.00	0.00	0.00	0.00	0.00	0.00		No
CR-8	Significant accident during construction	No Impact	0.00	0.00	0.00	0.00	0.00	0.00		No
CR-10	Fish window in Wandering Creek	No Impact	0.00	0.00	0.00	0.00	0.00	0.00		No
CR-11	Non-compliance with permits during construction	No Impact	0.00	0.00	0.00	0.00	0.00	0.00		No
CR-12	Extended overheads as a function of project delays	No Impact	0.0	0.0	0.00	0.0	0.0	0.00		No

SHRP2 Risk Management Template

HELP

Step 11 - Mitigated Project Performance

Schedule Duration Assumption:
Some risks in a phase will occur concurrently, while others will occur sequentially.

Update Risk Analysis Summary | <==BACK | HOME | FWD==>

Mitigated Project Cost, Duration, and Disruption Performance

Project Phase	Base + Implementation			Residual Risk			Total (Base + Implementation + Residual Risk)			
	Cost (CY $M)	Duration (months)	Disruption (M-hrs)	Cost (CY $M)	Duration (months)	Disruption (M-hrs)	Cost (CY $M)	Duration (months)	Disruption (M-hrs)	Cost (YOE $M)
Planning	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Scoping	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Prelim Design/Environmental Process	1.19	12.00	0.00	0.13	1.47	0.00	1.32	13.47	0.00	1.34
Environmental Permits	0.00	6.00	0.00	0.00	0.31	0.00	0.00	6.31	0.00	0.00
ROW/Util/RR	3.05	12.00	0.20	2.35	0.70	0.00	5.40	12.70	0.20	5.67
Final Design	0.20	6.00	0.00	0.00	0.75	0.00	0.20	6.75	0.00	0.21
Procurement	0.00	6.00	0.00	0.22	0.29	0.00	0.22	6.29	0.00	0.23
Construction	11.85	16.00	0.50	1.88	0.38	-0.02	13.73	16.38	0.48	14.76
Operations & Maintenance	0.00	600.00	1.40	0.00	0.00	0.00	0.00	600.00	1.40	
Replacement	0.00	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.70	
Total (through Construction)	**16.29**		**0.70**	**4.58**		**-0.02**	**20.87**		**0.68**	**22.21**
Total (through Replacement)	**16.29**		**2.80**	**4.58**		**-0.02**	**20.87**		**2.78**	**22.21**

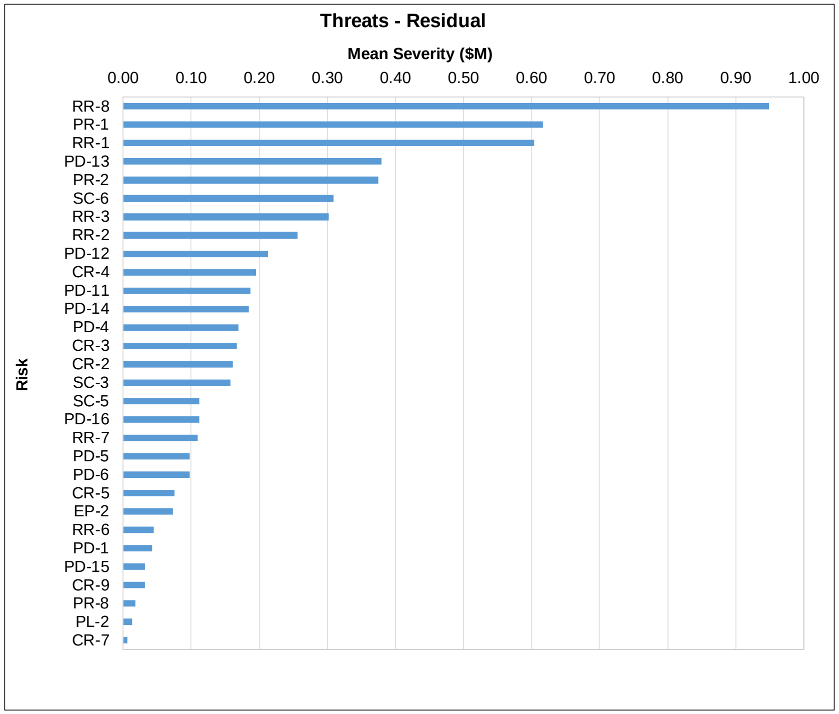
Project Schedule Performance (Unmitigated vs. Mitigated)

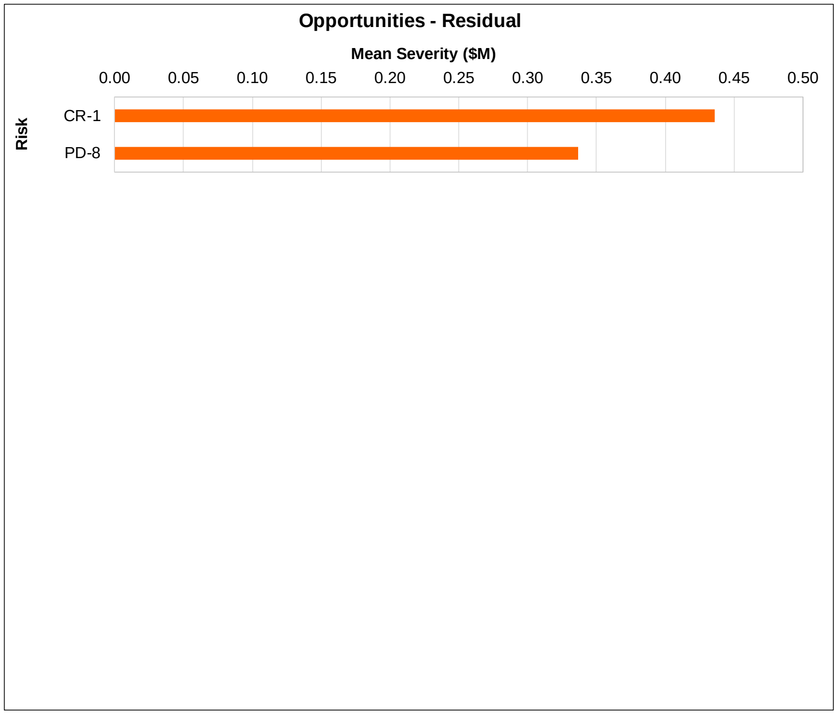
Project Phase	Unmitigated Project Schedule Performance (from step 6)						Mitigated Project Schedule Performance						Mean
	Duration (Months/ Date)	Early Start	Early Finish	Late Start	Late Finish	Float (months)	Duration (Months/ Date)	Early Start	Early Finish	Late Start	Late Finish	Float (months)	Severity YOE($M)
Planning	0.00	12/1/2009	12/1/2009	12/1/2009	12/1/2009	0.00	0.00	12/1/2009	12/1/2009	12/1/2009	12/1/2009	0.00	0.01
Scoping	0.00	12/1/2009	12/1/2009	12/1/2009	12/1/2009	0.00	0.00	12/1/2009	12/1/2009	12/1/2009	12/1/2009	0.00	0.58
Design Funding Date	12/1/2009		12/1/2009		12/1/2009	0.00	12/1/2009		12/1/2009		12/1/2009	0.00	0.00
Prelim Design/Environmental Process	13.47	12/1/2009	1/14/2011	12/1/2009	1/14/2011	0.00	13.47	12/1/2009	1/14/2011	12/1/2009	1/14/2011	0.00	1.18
Environmental Permits	6.31	1/14/2011	7/25/2011	2/8/2011	8/19/2011	0.81	6.31	1/14/2011	7/25/2011	1/26/2011	8/6/2011	0.39	0.07
ROW/Util/RR Funding Date	12/1/2009		12/1/2009		2/17/2012	26.59	12/1/2009		12/1/2009		2/4/2012	26.17	0.00
ROW/Util/RR	13.13	1/14/2011	2/17/2012	1/14/2011	2/17/2012	0.00	12.70	1/14/2011	2/4/2012	1/14/2011	2/4/2012	0.00	2.27
Construction Funding Date	12/1/2009		12/1/2009		2/8/2011	14.30	12/1/2009		12/1/2009		1/27/2011	13.88	0.00
Procurement	6.29	1/14/2011	8/19/2011	2/8/2011	8/19/2011	0.00	6.29	1/14/2011	8/6/2011	1/27/2011	8/6/2011	0.00	1.01
Final Design	6.75	8/19/2011	3/11/2012	8/19/2011	8/13/2012	5.10	6.75	8/6/2011	2/27/2012	8/6/2011	7/17/2012	4.63	0.00
Construction	16.85	9/18/2011	2/11/2013	9/18/2011	2/11/2013	0.00	16.38	9/5/2011	1/15/2013	9/5/2011	1/15/2013	0.00	0.20
Operations & Maintenance	600.00	2/11/2013	1/20/2063	2/11/2013	1/20/2063		600.00	1/15/2013	12/24/2062	1/15/2013	12/24/2062		
Replacement	0.00	1/20/2063	1/20/2063	1/20/2063	1/20/2063		0.00	12/24/2062	12/24/2062	12/24/2062	12/24/2062		
Project Start Date	**12/1/2009**						**12/1/2009**					**Total**	5.32
Construction Finish Date	**2/11/2013**						**1/15/2013**						
Project Duration (months)	**38.45**						**37.55**						

SHRP2 Risk Management Template

HELP **Step 12 - Mitigated Risk Ranking Plots**

<===BACK HOME FWD===>





STRATEGIC HIGHWAY RESEARCH PROGRAM

FHWA SHRP2 R09 Train-the-Facilitator Workshop

EVALUATION

Phoenix, Arizona
October 27-28, 2016

Arizona Department of Transportation

1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree 0 = N/A

1. The workshop will help improve my job performance	1	2	3	4	5	0
2. Subject matter was well organized.	1	2	3	4	5	0
3. The workshop goals and objectives were clear.	1	2	3	4	5	0
4. The presentation followed the workshop materials.	1	2	3	4	5	0
5. Exercises aided in my understanding and skill development.	1	2	3	4	5	0
6. The workshop provided opportunities for me to participate.	1	2	3	4	5	0
7. Pace was appropriate for the amount of content covered.	1	2	3	4	5	0
8. Workshop materials were clear and legible.	1	2	3	4	5	0
9. The workshop advanced my knowledge of complex projects.	1	2	3	4	5	0
10. The workshop will help me assess and manage complex projects.	1	2	3	4	5	0
11. Was a satisfactory learning experience.	1	2	3	4	5	0

Continue on other side – Please turn over

1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree 0 = N/A

The Instructors …	Instructor #1 Jerry DiMaggio	Instructor #2 Paul Dalbey
Clearly stated all learning outcomes	1 2 3 4 5 0	1 2 3 4 5 0
Made appropriate transitions & summaries throughout workshop	1 2 3 4 5 0	1 2 3 4 5 0
Kept discussions focused on relevant topics	1 2 3 4 5 0	1 2 3 4 5 0
Consistently employed question and answer techniques	1 2 3 4 5 0	1 2 3 4 5 0
Provided for application of content through experiences	1 2 3 4 5 0	1 2 3 4 5 0
Provided positive feedback to the class	1 2 3 4 5 0	1 2 3 4 5 0
Encouraged participants to share work experience & background	1 2 3 4 5 0	1 2 3 4 5 0
Explained theories and concepts effectively	1 2 3 4 5 0	1 2 3 4 5 0
Related the subject matter to my job	1 2 3 4 5 0	1 2 3 4 5 0
Used appropriate visual aids in support of learning outcomes	1 2 3 4 5 0	1 2 3 4 5 0
Clearly demonstrated subject matter expertise	1 2 3 4 5 0	1 2 3 4 5 0
Provided a positive learning environment	1 2 3 4 5 0	1 2 3 4 5 0
Were enthusiastic	1 2 3 4 5 0	1 2 3 4 5 0
Increased my interest in the subject	1 2 3 4 5 0	1 2 3 4 5 0
Provided a satisfactory learning experience	1 2 3 4 5 0	1 2 3 4 5 0

1. The instructors were the most effective at…

____

____

2. The instructors were the least effective at…

____

____

3. Describe any part of the course that needs improvement.

____

____

4. Please explain how this workshop was relevant to your job or your job responsibilities.

____

____

NOTES

NOTES