Appendix 9

Cost Risk Assessment

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I. EXECUTIVE SUMMARY

The attached Cost Risk Assessment report for the City of Henderson's (COH) proposed improvements to the Interstate 215 (I-215) and Interstate 515 (I-515) system interchange identifies project threats and opportunities which could have an effect on project cost and/or budget.

In preparing this Cost Risk Assessment (CRA), a risk based estimate was prepared to model project risks assuming all risks would be accepted (pre-response) as well as preparing the post-response estimate assuming a proactive risk management plan was implemented.

The following tables present results from the November 2019 CRA and are intended as a quick summary for COH leadership and management.

Risk-Adjusted Cost Results (in Millions – YOE $'s)				
Scenario	Base Cost	Cost Range		
		10th Percentile	70th Percentile	90th Percentile
Option 1				
Pre-Response	$294.2	$309.2	$329.2	$337.3
Post-Response		$307.9	$327.7	$336.1
Option 2				
Pre-Response	$261.9	$282.9	$299.0	$306.0
Post-Response		$281.8	$297.9	$305.1

Table E-1 – Risk Adjusted Cost Results (in Millions – YOE $'s)

Risk-Adjusted Project Completion Date				
Scenario	Base Completion Date	Project Completion Date Range		
		10th Percentile	70th Percentile	90th Percentile
Pre-Response	December 2027	October 2026	October 2027	June 2028
Post-Response		August 2026	August 2027	April 2028

Table E-2 – Risk Adjusted Project Completion Date

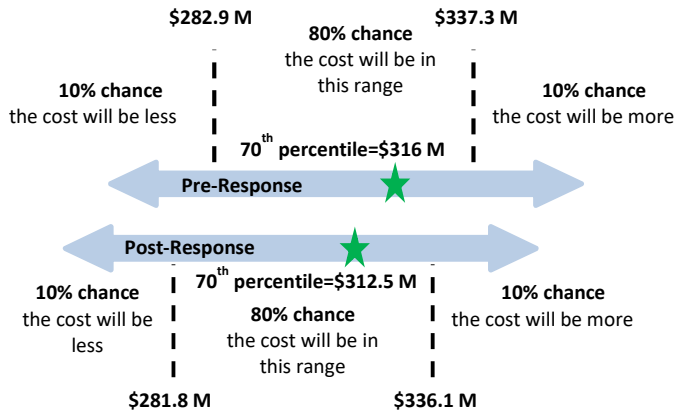
Figure E-1 on the attached page presents a one-page snapshot of I-215/I-515 Henderson Interchange project with respect to overall benefits, costs and schedule.

Project Summary	I-215/I-515 Henderson Interchange November 2019	

Project Description

- Construct improvements to the I-215 and I-515 interchange
- Construct improvements to Lake Mead Parkway
- Additional improvements on I-515 north of the system interchange
- Two options currently under evaluation

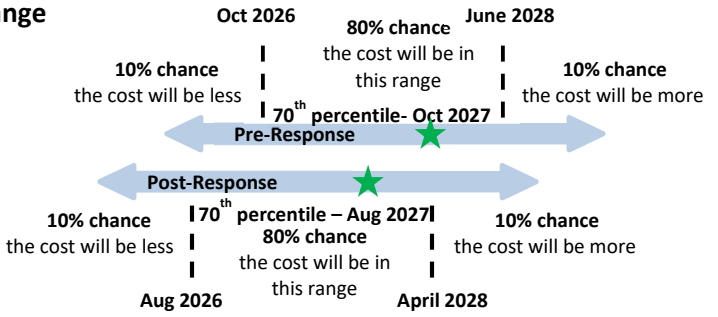
CRA Cost Range



Project Benefits

- Increase capacity
- Reduce overall interchange delay
- Reduce weaving movements
- Improve safety

CRA Schedule Range



Key Project Schedule Risks

Threats

- Additional Right-of-Way Impacts
- Funding Delay and Uncertainty
- Construction Uncertainty
- UPRR Coordination
- NEPA Uncertainty

Opportunities

- Categorical Exclusion versus Environmental Assessment
- Alternative Delivery
- Expedited Funding

Key Project Cost Risks

Threats

- Structure Cost Uncertainties
- Borrow Embankment
- Funding Escalation Costs
- UPRR Escalation
- Minor Change Orders

Level of Project Completion:	Low Medium High	January 2020

Figure E-1 - I-215/I-515 Henderson Interchange Project Summary

1. INTRODUCTION

The report summarizes a risk-based cost and schedule analysis that was completed by CA Group for the City of Henderson's (COH) proposed improvements to the Interstate 215 (I-215) and Interstate 515 (I-515) system interchange. Two potential options have been identified that will provide improvements to the interchange and adjacent roadways that will enhance interchange operations, capacity, and safety. The following study documents the Risk Assessment Workshop that was conducted by CA Group on November 18, 2019.

The purpose of the workshop was to:

- Analyze and document the potential range of uncertainty in both project cost and schedule due to risks (threats and/or opportunities) to assist in selecting a locally preferred alternative;
- Identify any significant risks or opportunities unique to the different alternatives which would be considered in the selection of the preferred alternative; and
- Identify and prioritize key cost and schedule risks and opportunities for the proposed alternatives.

The workshop and subsequent statistical analysis followed an approach very similar to the Washington State Department of Transportation's Cost Estimate Validation process (CEVP®) and in accordance with the Nevada Department of Transportation's (NDOT) Risk Management and Risk-Based Cost Estimation Guidelines.

The Risk Assessment Workshop consisted of several subject matter experts that where familiar with the project and potential risks and opportunities. Workshop attendees included the following individuals:

- Facilitator – Chad Anson, CA Group
- Tom Davy – City of Henderson
- Eric Hawkins – City of Henderson
- Scott Jarvis – City of Henderson
- Maylinn Rosales – City of Henderson
- Mary Baer – City of Henderson
- Lynnette Russell – NDOT Project Management
- David Bowers – NDOT Project Management
- Tim Ruguleiski – NDOT Construction
- Neil Kumar – NDOT Construction
- David Chase – NDOT Structures
- Jim Caviola – CA Group
- Jim Mischler – CA Group
- Valerie Flock – CA Group
- Tammy Michels – CA Group

The outcomes of the workshop and Risk Assessment Report are intended to assist in providing COH recommendations on the estimated overall project cost, schedule, risk management strategies that can be implemented provide the best value project possible throughout the project development process and locally preferred alternative selection.

2. PROJECT DESCRIPTION AND ASSUMPTIONS

2.1. Project Scope and Phasing

The City of Henderson is currently conducting a feasibility study to identify possible upgrades to the existing system interchange at Interstate 215 (I-215) and Interstate 515 (I-515). The study is currently evaluating two different options to move forward into the environmental clearance process, also known as the NEPA process.

Figure 1 – Feasibility Study Limits

The feasibility study limits, illustrated in Figure 1, shows the roadway network and potential limits of improvements. The existing interchange configuration includes direct-connect ramps from I-215 to I-515 for all connecting movements. I-215 eastbound terminates into Lake Mead Parkway, while westbound Lake Mead Parkway becomes I-215 westbound.

Figure 2 – Existing Interchange Looking East

Currently two different options are being proposed by the City of Henderson. Option 1 consists of widening and construction of new bridges to maintain a similar look and feel of the interchange. Improvements would modify adjacent service interchange access and be constructed primarily within existing right-of-way.

Option 2 requires substantial demolition and reconstruction of the interchange to develop a double diverging diamond layout which provides direct access from each freeway without large direct-connection bridge structures. More complicated bridges structures are required however for the crossing of mainline freeway to create the "diverging diamond" layout.

Additional details on the alternative layouts can be found in the *Henderson Interchange Feasibility Study*.

2.2 Strategy, Key Conditions and Assumptions:

The following is a compilation of assumptions, existing conditions, analyzed forecasts and project strategies at the time of the workshop.

- Funding
  - Funding has not fully been identified or incorporated into a short range funding plan.
- Design
  - Design Level
    - Design for the project is currently at 15-20%
    - There are a handful of possible options that will need to be evaluated further during NEPA and final design to address public and stakeholder concerns.
  - Landscaping
    - Maximum budget of 3% of construction. Minimal design completed at time of workshop.
  - Structural
    - Standard bridge types (cast-in-place post tensioned and steel girders) and construction techniques are assumed.
  - Geotechnical
    - Previous studies and borings are the basis of the concept design.
    - No project specific borings have been performed.
  - Pavement
    - NDOT Wizard was utilized for roadway costs, including pavement section costs.
  - Design Deviations or Exceptions
    - No design deviations for NDOT policies or FHWA design exceptions are anticipated at this time.
- Environmental Documentation
  - Project will require a NEPA process

Figure 3 – Recommended Alternative

- Permitting
  - No significant environmental permits are anticipated (excluding USACOE 404).
  - Contractor will obtain necessary construction permits.
- Right-of-Way
  - No right-of-way acquisitions are anticipated.
- Utilities
  - No significant utility impacts anticipated since improvements are being done within right-of-way.
- Other Stakeholders

- NDOT
- RTC
- Adjacent business and property owners

- Procurement
  - Delivery Method
    - One phase of design-bid-build delivery.
    - The Project Delivery Selection Approach (PDSA) process will used to determine the delivery method. The PDSA is not yet scheduled.
  - Market
    - A very competitive bidding environment is assumed.
- Construction
  - Maintenance of Traffic
    - A detailed maintenance of traffic plan has not yet been developed.
  - Construction Phasing
    - Constructed as one project.
- Priority
  - Project is a major priority for the City of Henderson.

3. INPUTS

3.1 Base Project Schedule/Flow Chart

In order to provide an inclusive cost and schedule quantitative risk assessment, a cost-based schedule model was utilized. A duration "flow chart" was developed for the project that graphically depicts key project milestones at a level of detail appropriate for the workshop. The flow chart identified key activities and predecessor relationships that exist between key milestones. This flow chart then becomes the basis for modeling the project schedule (including delays and opportunities due to risk events) and to calculate inflated, year-of-expenditure costs for each activity identified. Appendix B provides the risk assessment workshop flow chart for the project as evaluated in this report.

3.2 Scenarios

A scenario was run for pre-response and post-response mitigation in current year costs for each option. It was assumed that the project phasing would be similar for either scenario. The pre-response scenario assumes no mitigation strategies are developed or implemented. The post-response strategy assumes NDOT is proactive in mitigating and/or monitoring risks. The difference in costs of the two strategies help NDOT develop a cost/benefit of the level effort that should applied to mitigating and monitoring risk for the project. A significant difference between scenario costs indicates a significant effort should be made while a minor difference in costs between the scenarios may warrant less effort in risk mitigation and monitoring.

3.3 Exclusions from the Risk Assessment

This risk assessment workshop was conducted to provide the best information available for COH leadership and senior management to make educated decisions on the project and alternatives during this phase of the project. When reviewing the results, it is important to consider that this is snapshot of the project and that the project is still in the early phases of development requiring some items to be excluded. For this analysis significant exclusions include:

- The potential for significant changes to the current design (including additional lanes, ramps, project limits) were not considered. It is recognized that such changes might occur as a result of funding delays, change in prioritization, and/or changes in regional development and economics.
- Significant changes to the phasing of the project were not considered.
- Other significant changes to the scope of this project were not considered.

3.4 Base Project Cost

A base cost estimate was developed for the project through the use of NDOT's Wizard cost estimation program. The base estimate was developed by calculating the length and laneage of new roadway and area of bridge work. Other items such as traffic control, signing, ITS and incidentals (based on NDOT WIZARD Guidance) were assigned a percentage of construction cost. Once this percentage was assigned, the overall cost was checked for reasonableness and the percentage modified, as necessary. Tables 1 and

2 provide a summary of the base cost estimates for each option. It should be noted, that since these are base estimates, no contingencies were added.

Description	Baseline Cost
Roadway	$43,950,320
Structures	$126,700,831
Traffic	$638,000
Drainage	$8,463,959
Utilities	$0
Bid Item Subtotal	**$179,753,110**
Landscaping and Aesthetics (3%)	$5,392,593
Additional Items (10%-Drainage)	$17,128,915
Traffic Control (10%)	$17,975,311
Roadside Safety (3%)	$5,392,593
Erosion Control (0.5%)	$898,766
Subtotal	$226,541,288
Mobilization (7%)	$15,857,890
Contract Total	**$242,399,178**
Preliminary & Final Engineering (4%)	$9,695,967
Preliminary R/W Engineering	$5,000
NEPA (0.2%)	$484,798
Construction Engineering (15%)	$36,359,877
Administration (1%)	$2,423,992
Legal (1%)	$2,423,992
Subtotal	$293,792,804
Right-of-Way Acquisition	$0
Railroad Flagging	$375,000
Environmental Considerations (0%)	$0
Project Total (Base Cost)	**$294,167,804**

Table 1 – Option 1 Overall Base Cost Estimate Summary (2019 Dollars)

Description	Baseline Cost
Roadway	$54,363,209
Structures	$97,050,748
Traffic	$638,000
Drainage	$7,478,090
Utilities	$500,000
Bid Item Subtotal	**$160,030,047**
Landscaping and Aesthetics (3%)	$4,800,901
Additional Items (10%-Drainage)	$15,255,196
Traffic Control (10%)	$16,003,005
Roadside Safety (3%)	$4,899,901
Erosion Control (0.5%)	$800,150
Subtotal	$201,690,200
Mobilization (7%)	$14,118,314
Contract Total	**$215,808,514**
Preliminary & Final Engineering (4%)	$8,632,341
Preliminary R/W Engineering	$5,000
NEPA (0.2%)	$431,617
Construction Engineering (15%)	$32,371,277
Administration (1%)	$2,158,085
Legal (1%)	$2,158,085
Subtotal	$261,564,920
Right-of-Way Acquisition	$0
Railroad Flagging	$375,000
Environmental Considerations (0%)	$0
Project Total (Base Cost)	**$261,939,920**

Table 2 – Option 2 Overall Base Cost Estimate Summary (2019 Dollars)

All project costs are currently anticipated to be borne by through various funding sources including Federal funding. A more detailed summary of the base cost estimates prepared for each option is presented in Appendix A.

Uncertainty

A cost estimate is "snapshot" of the anticipated project costs based on the preparer's perception of construction costs at that given time. Many factors will dictate the estimate including level of detail available, current construction market and size of the project and/or quantities. Nevertheless; there will always be uncertainty in a base cost estimate due to these factors. Uncertainty can be applied to a project cost estimate by giving range of costs and quantities.

The estimator may establish this uncertainty range by analyzing unit costs and quantities based on project location, scale of quantities, construction market and availability of materials. Depending on the

level of design, others factors may play into uncertainty such as available geotechnical information, NEPA constraints, right-of-way, and type of project delivery. Tables 3 and 4 show the Base Project Cost Uncertainty by key project components for each option.

In establishing the uncertainty ranges for each item, consideration was given to factors that might affect quantities or bid prices, such as project location (rural vs. urban), quantities (large or small), items that are difficult to construct or site constraints, methods of payments, timing of advertisement, specialty work, geotechnical and project delivery methods. Uncertainty is typically expressed in terms of a percentage (of the quantity and/or unit cost) lower or higher than the base.

Activity	Project Cost		
	Low	Base	High
Preliminary & Final Engineering	$7,957,719	$9,695,967	$10,564,779
Preliminary R/W Engineering	$5,000	$5,000	$5,000
NEPA	$397,886	$484,798	$528,239
Construction Engineering	$29,841,445	$36,359,877	$39,617,920
Administration	$1,989,430	$2,423,992	$2,641,195
Legal	$1,989,430	$2,423,992	$2,641,195
Right of Way Acquisition	$0	$0	$0
Environmental Considerations	$0	$0	$0
Construction	$199,192,965	$242,774,178	$264,494,467
Total	**$241,373,875**	**$294,167,804**	**$320,492,795**

Table 3 – Option 1 Base Cost Uncertainty by Activity

Activity	Project Cost		
	Low	Base	High
Preliminary & Final Engineering	$7,405,984	$8,632,341	$9,514,758
Preliminary R/W Engineering	$5,000	$5,000	$5,000
NEPA	$370,299	$431,617	$475,738
Construction Engineering	$27,772,441	$32,371,277	$35,680,342
Administration	$1,851,496	$2,158,085	$2,378,689
Legal	$1,851,496	$2,158,085	$2,378,689
Right of Way Acquisition	$0	$0	$0
Environmental Considerations	$0	$0	$0
Construction	$185,399,604	$216,183,515	$238,243,945
Total	**$224,656,320**	**$261,939,920**	**$288,677,161**

Table 4 – Option 2 Base Cost Uncertainty by Activity

Escalation Rates

Escalation rates are a measurement of change (usually increase) in project costs due to inflation, market costs and the regional and national economy over the lifetime of a project. In this analysis, escalation is applied to key project activities as outlined in the project schedule including NEPA, final design, utilities

and construction costs. With escalation, not only do project delays extend the duration of the project, they will typically increase final project costs. Escalation rates used for this project are per NDOT's Escalation Rates Forecast Technical Memorandum dated January 2, 2019. Those rates are shown in Table 5.

Table 1. Current NDOT Escalation Rate Forecasts									
Year	Engineering			Right-of-Way			Construction		
	10%	50% (Median)	90%	10%	50% (Median)	90%	10%	50% (Median)	90%
2018	0.42%	1.12%	1.82%	3.65%	5.69%	7.73%	0.96%	2.15%	3.36%
2019	1.28%	2.17%	3.05%	1.73%	4.41%	7.03%	1.49%	2.46%	3.77%
2020	1.13%	2.35%	3.31%	0.08%	3.47%	6.66%	1.72%	2.83%	4.14%
2021	0.50%	2.08%	3.59%	-0.07%	3.89%	7.45%	1.56%	2.88%	4.23%
2022	1.05%	2.37%	3.63%	-0.90%	3.61%	7.44%	1.79%	3.07%	4.40%
2023	0.75%	2.10%	3.37%	-0.95%	3.90%	7.83%	2.13%	3.49%	4.86%
2024	0.70%	2.40%	3.94%	-1.56%	3.77%	7.83%	1.83%	3.13%	4.48%
2025	0.55%	2.45%	4.14%	-2.35%	3.53%	7.87%	2.37%	3.75%	5.01%
2026	0.30%	2.21%	3.89%	-1.71%	4.18%	8.51%	2.20%	3.57%	4.84%
2027+	0.05%	1.96%	3.64%	-1.06%	4.82%	9.16%	2.03%	3.40%	4.67%
Average	---	**2.12%**	---	---	**4.13%**	---	---	**3.07%**	---

Table 5 – Escalation Rates per NDOT's Escalation Rates Forecast Technical Memorandum

3.5 Risks

During the Risk Assessment Workshop, uncertainty in the base project costs and schedule were identified and characterized. This uncertainty included both threats and opportunities that could impact the project scope, schedule or budget. These threats and opportunities have been compiled into a risk register which is presented in Appendix C. Minor items have still been noted in the Risk Register for monitoring throughout the project in the event they become significant risk/opportunity factors. The Risk Register provides the City more than a summary of potential events that have been considered in the risk-based estimate and schedule; it provides the Project Manager a list of items that need to be monitored and potential strategies that should be implemented to reduce the risk and hopefully avoid significant events impacts to the project.

4. ANALYSIS

4.1 Model

The inputs developed in the workshop (including base cost, schedule, risk, opportunities and uncertainties) were entered into @RISK software. @RISK is a probabilistic, integrated model which utilizes Monte Carlo simulation techniques to generate probability distributions of cost and schedule while also prioritizing risk rankings. The simulation generates 5,000 independent potential outcomes and provides a statistical compilation of selected results. In order to accommodate inflation and true year-of-expenditure dollars; the cost of each flowchart activity was escalated from the estimate reference date to the activity mid-point (including consideration of delays or accelerations due to events) according to the specified escalation rate.

4.2 Pre-Response Results

The following section provides a summary of various significant cost results from the workshop and risk-based analysis based on the pre-response scenario for each option. The pre-response scenario assumes no risk management strategies are implemented.

It should be noted that the following is a "snapshot" of the project based on information available at the workshop. As the project evolves and more information is developed, identified risks should be mitigated therefore reducing, or "retiring", those risks that could impact the project. However, it is likely as the project progresses; new uncertainties may present themselves and will need to be recognized as part of the risk-based estimate and schedule. There is an adherent opportunity in implementing risk management strategies that as the project progresses and risks are retired; the risk-based estimate standard deviation will decrease thereby reducing the seventy-percentile cost and increasing confidence level.

Probability distributions for total overall project cost pre-response (current year dollars) are shown for each option in Figures 3 and 4 in probability mass functions (PMFs) and cumulative distribution functions

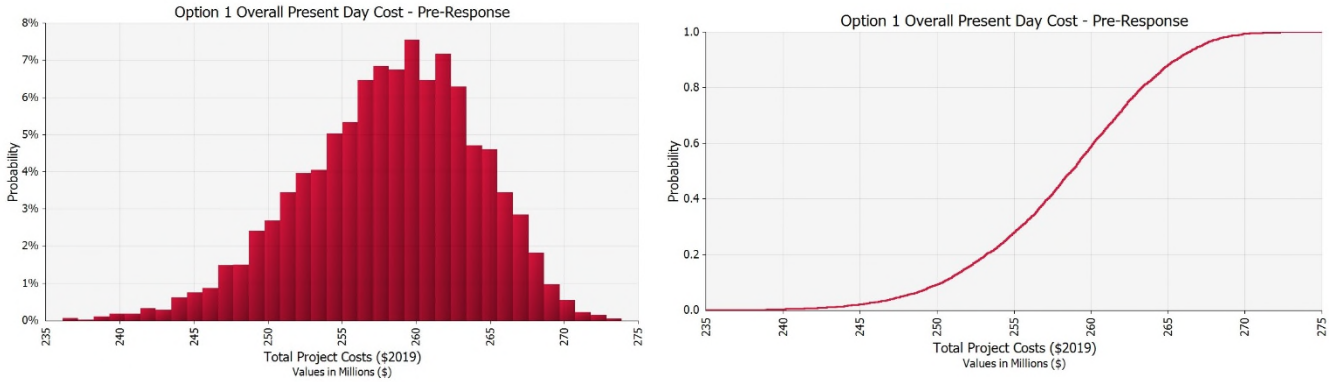


Figure 3 – Option 1 - Probability Distribution for Overall Total Present Day Cost ($2019) – Pre-Response, presented in two ways: a) probability mass function (PMF); b) cumulative distribution function (CDF)

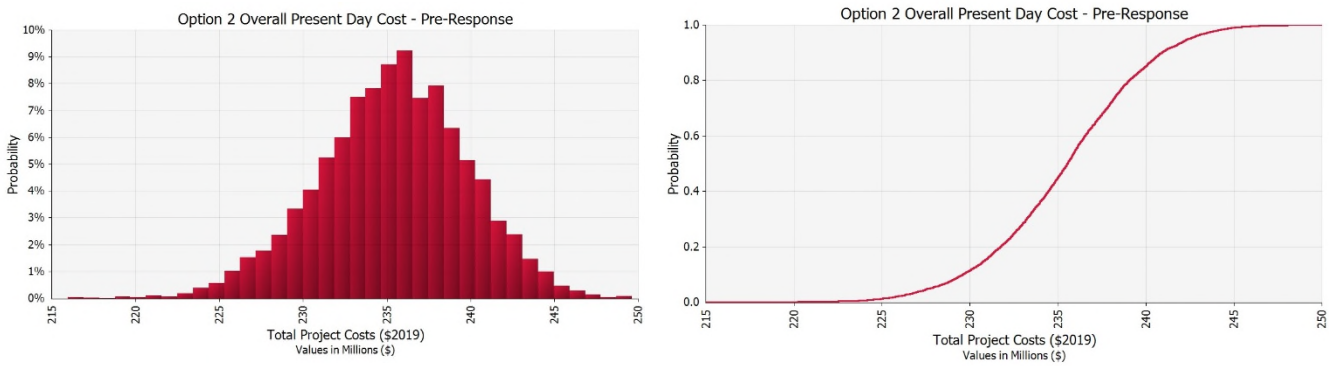


Figure 4 – Option 2 - Probability Distribution for Overall Total Present Day Cost ($2019) – Pre-Response, presented in two ways: a) probability mass function (PMF); b) cumulative distribution function (CDF)

(CDFs) format. These probability distributions reflect the base cost combined with identified project risks and opportunities with no mitigation or on-going risk or opportunity management activities.

The PMF provides a graphical measure that portrays the range of values, including the most likely value as represented by the tallest bar on the graph. For example, in Figure 3, the most likely overall project cost in 2019 dollars will be approximately $259.3 million for Option 1. Figure 5 provides the same information in year of expenditure dollars with a most likely overall project cost of approximately $320.6 million for Option 1. Year of expenditure costs are calculated from based on an anticipated pre-response risk-based schedule which is shown in Figure 7. Figure 7 anticipates the most likely completion to be June 2027 based on pre-response activities.

A CDF represents the cumulative probability of not exceeding a particular value (also known as a percentile or confidence level). For example, from the CDFs shown in Figure 3, the 70th percentile means that there is a 70 percent likelihood that the total cost for the entire project will be less than or equal to approximately $261.5 million in 2019 dollars for Option 1. Option 2 is shown in Figure 4 with a 70 percent likelihood that the total cost for the entire project will be less than or equal to $237.7 million in 2019 dollars.

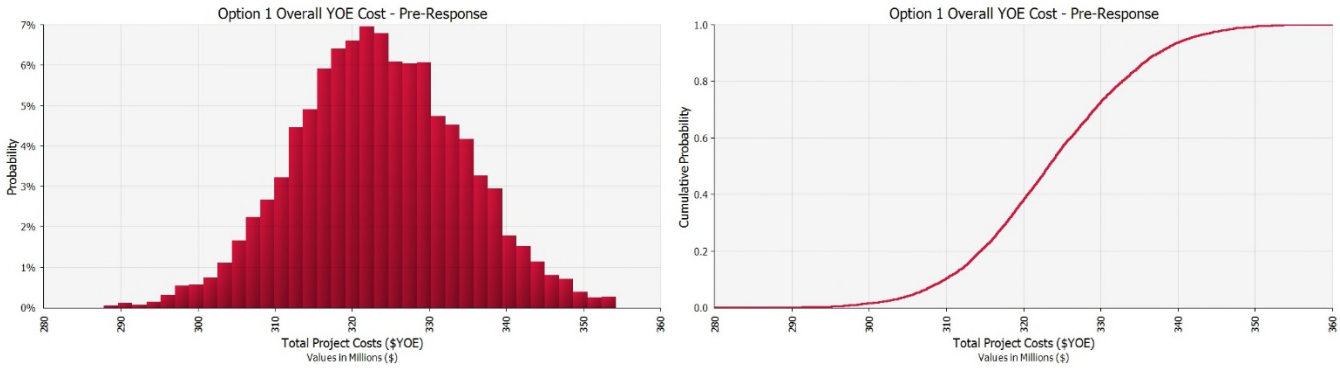


Figure 5 – Option 1 - Probability Distribution for Overall Total Year of Expenditure Cost – Pre-Response, presented in two ways: a) probability mass function (PMF); b) cumulative distribution function (CDF)

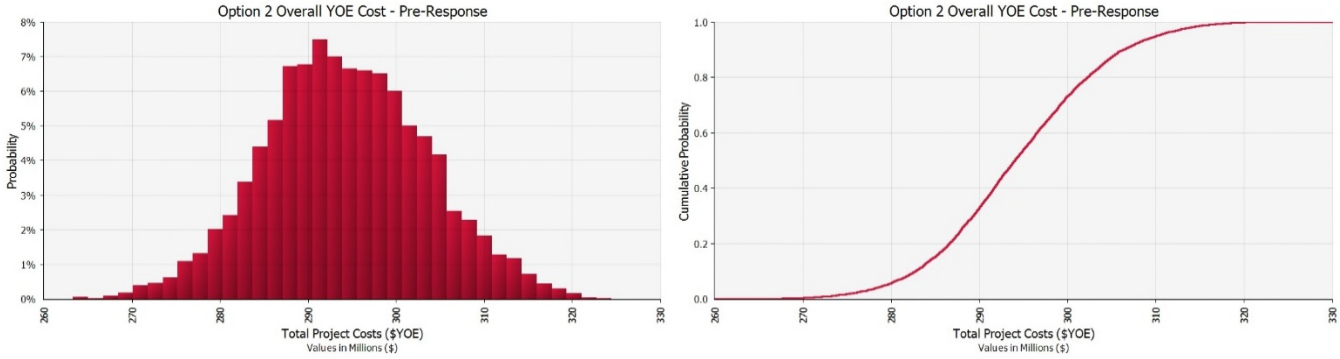


Figure 6 – Option 2 - Probability Distribution for Overall Total Year of Expenditure Cost – Pre-Response, presented in two ways: a) probability mass function (PMF); b) cumulative distribution function (CDF)

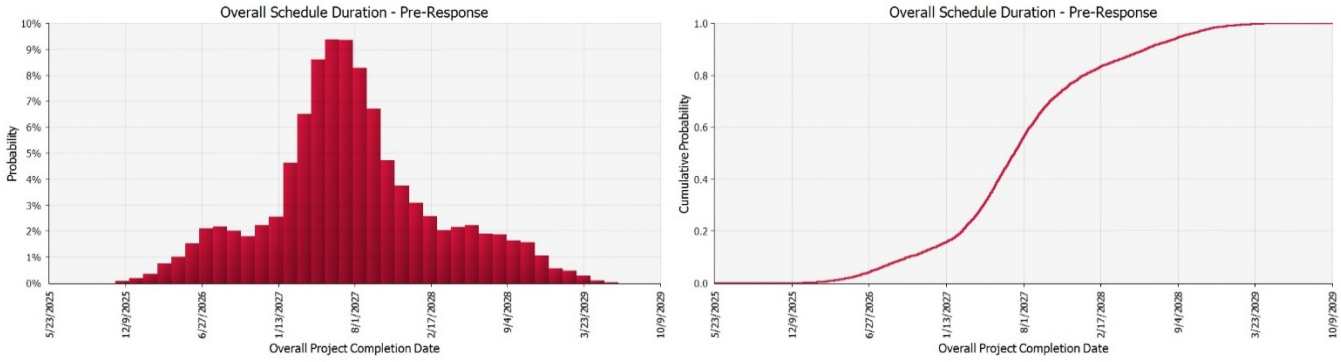


Figure 7 – Probability Distribution for Overall Schedule Duration – Pre-Response, presented in two ways: a) probability mass function (PMF); b) cumulative distribution function (CDF)

4.3 Post-Response Results

Sound project management execution consists of the agencies and those involved to proactively manage risk and opportunities; thereby, reducing potential increases and costs and schedule duration. As part of the workshop, the group identified the potential reduction in risks based on proactive management (Post-Response) and is shown in Figures 6 through 8.

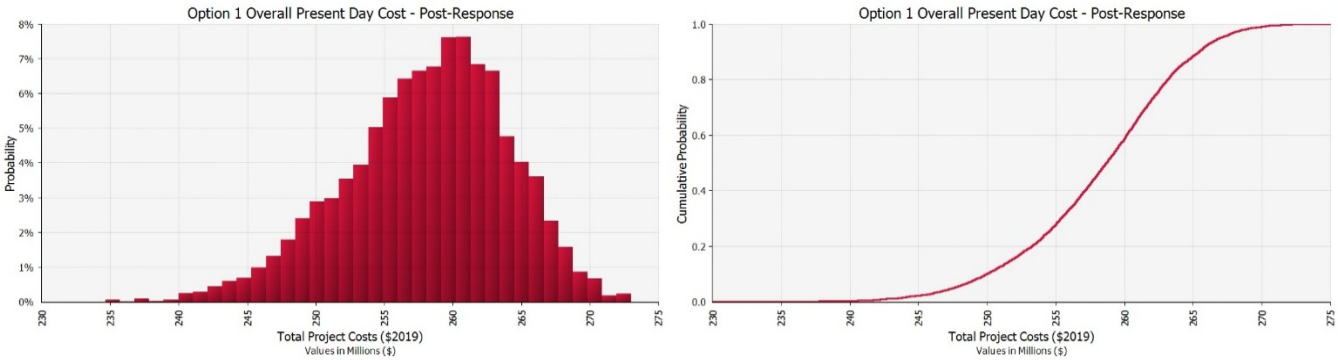


Figure 8 – Option 1 - Probability Distribution for Overall Total Present Day Cost ($2019) – Post-Response, presented in two ways: a) probability mass function (PMF); b) cumulative distribution function (CDF)

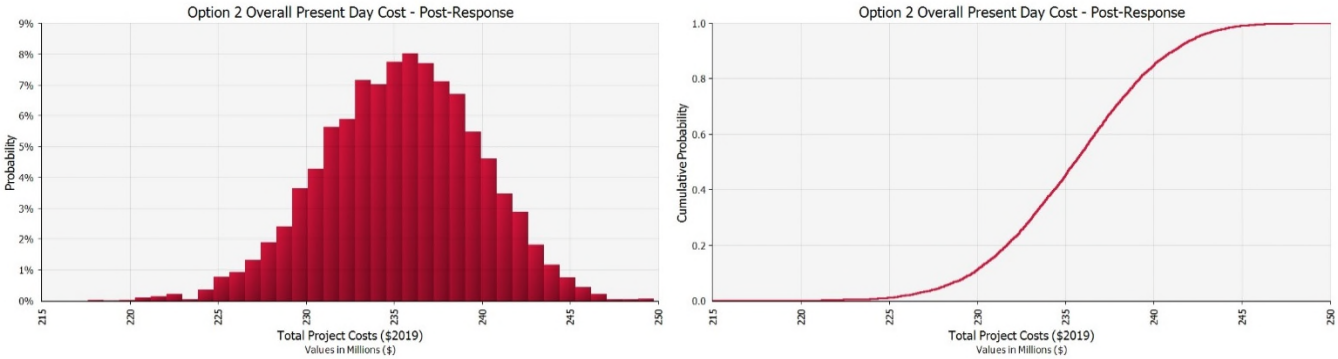


Figure 9 – Option 2 - Probability Distribution for Overall Total Present Day Cost ($2019) – Post-Response, presented in two ways: a) probability mass function (PMF); b) cumulative distribution function (CDF)

Similar to the pre-response graphs in Section 4.2, the schedule and cost analysis based on proactively managing risks and opportunities shows the project would most likely cost $259.5 million in 2019 dollars, $323.4 million in year of expenditure with an anticipated completion of February 2027 for Option 1. Option 2 would most likely be $233.6 million in 2019 dollars and $290.2 million in year of expenditure with the same completion timeframe as Option 1.

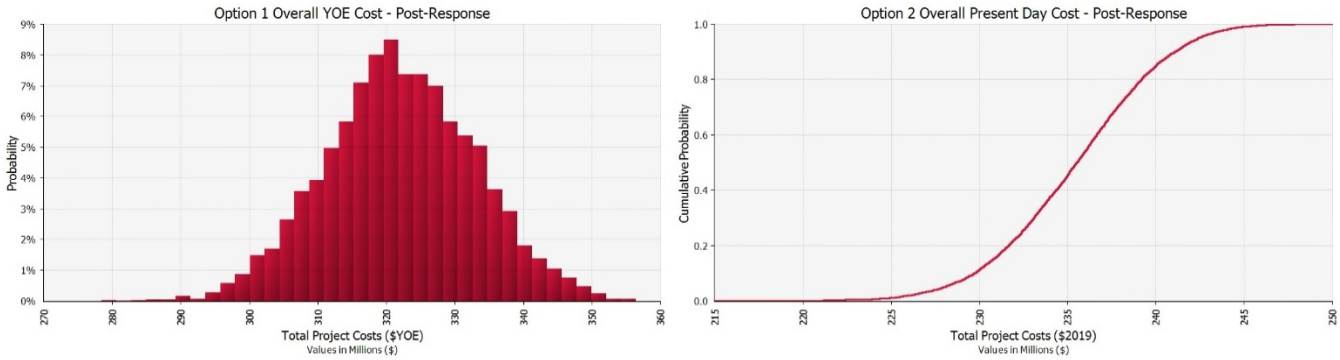


Figure 10 Option 1 – Probability Distribution for Overall Total Year of Expenditure Cost – Post-Response, presented in two ways: a) probability mass function (PMF); b) cumulative distribution function (CDF)

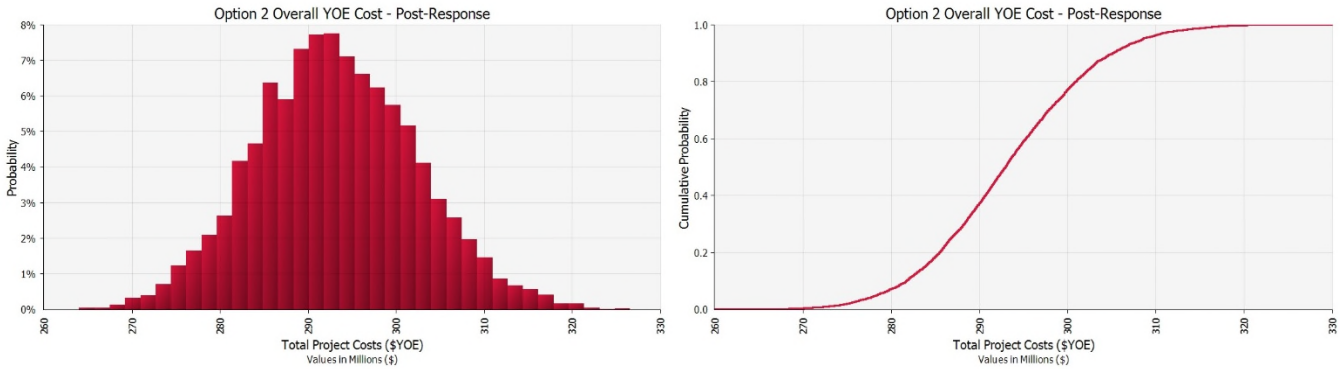


Figure 11 Option 2 – Probability Distribution for Overall Total Year of Expenditure Cost – Post-Response, presented in two ways: a) probability mass function (PMF); b) cumulative distribution function (CDF)

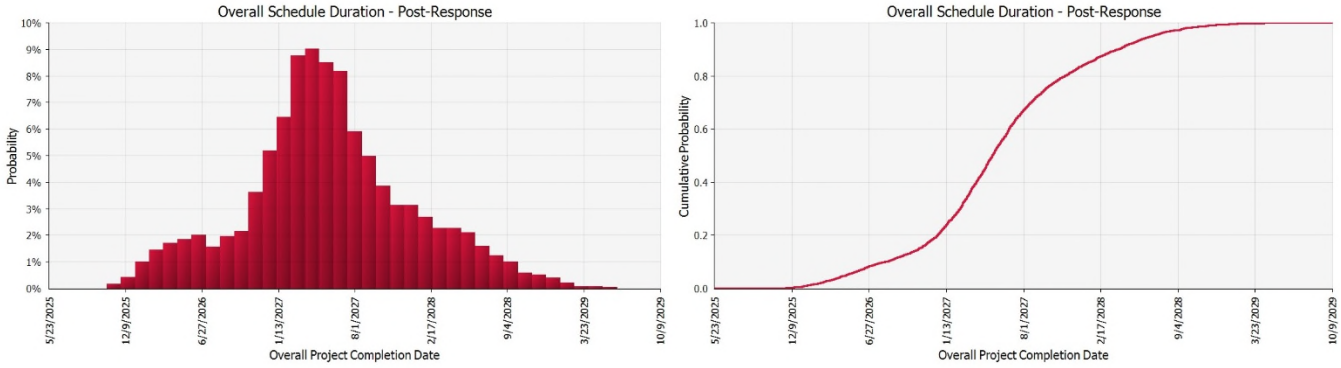


Figure 12 – Probability Distribution for Overall Schedule Duration – Post-Response, presented in two ways: a) probability mass function (PMF); b) cumulative distribution function (CDF)

Another method of presenting the project budget and schedule expectations to the general public and outside project stakeholders is by using the mid-80 percent confidence level. This range of cost and duration is bounded by the 10th percentile on the lower end and the 90th percentile on the higher end.

This will provide an 80 percent likelihood that the project costs and schedule will be completed within this range, and only a 20 percent likelihood that it will not. Table 6 provides a summary of the mid-80 percent confidence level range post-response.

Description	10th Percentile (Lower Limit)	90th Percentile (Upper Limit)
Option 1		
Total Project Cost (2019 Dollars)	$250.0 million	$265.4 million
Total Project Cost (YOE Dollars)	$307.9 million	$336.1 million
Option 2		
Total Project Cost (2019 Dollars)	$229.7 million	$241.1 million
Total Project Cost (YOE Dollars)	$281.8 million	$305.1 million
Duration (Either Option)		
Project Completion Date	August 2026	April 2028

Table 6 – Mid-80 Percent Confidence Level Range for the Overall Project Post-Response

Tables 7 and 8 provide a summary of various post-response probability distributions (i.e. confidence levels) for the overall project including current year cost, year of expenditure and project duration for each of the two proposed options.

	Total Project Cost (2019 $ Mil)	Total Project Cost (YOE $ Mil)	Overall Completion Date
Base	$294.2	$373.1	December 2027
Mean	$258.1	$322.1	May 2027
Standard Dev.	$5.9	$10.9	223 Days
5%	$247.6	$304.2	April 2026
10%	$250.0	$307.9	August 2026
15%	$251.8	$310.7	November 2026
20%	$253.2	$313.0	December 2026
25%	$254.4	$314.8	January 2027
30%	$255.4	$316.5	February 2027
35%	$256.3	$317.9	March 2027
40%	$257.1	$319.3	April 2027
45%	$257.9	$320.6	April 2027
50%	$258.7	$321.8	May 2027
55%	$259.4	$323.3	June 2027
60%	$260.1	$324.8	June 2027
65%	$260.9	$326.3	July 2027
70%	$261.6	$327.7	August 2027
75%	$262.4	$329.5	September 2027
80%	$263.1	$331.5	November 2027
85%	$264.1	$333.6	January 2028
90%	$265.4	$336.1	April 2028
95%	$266.9	$340.0	June 2028

Table 7 – Option 1 - Summary of Probability Distributions for Overall Cost and Schedule – Post Response

	Total Project Cost (2019 $ Mil)	Total Project Cost (YOE $ Mil)	Overall Completion Date
Base	$261.9	$332.2	December 2027
Mean	$235.5	$293.2	May 2027
Standard Dev.	$4.4	$9.1	223 Days
5%	$228.0	$278.4	April 2026
10%	$229.7	$281.8	August 2026
15%	$230.8	$283.8	November 2026
20%	$231.7	$285.5	December 2026
25%	$232.4	$286.8	January 2027
30%	$233.1	$288.3	February 2027
35%	$233.7	$289.5	March 2027
40%	$234.3	$290.7	April 2027
45%	$235.0	$291.8	April 2027
50%	$235.5	$293.0	May 2027
55%	$236.1	$294.1	June 2027
60%	$236.7	$295.3	June 2027
65%	$237.2	$296.5	July 2027
70%	$237.8	$297.9	August 2027
75%	$238.5	$299.4	September 2027
80%	$239.2	$300.9	November 2027
85%	$240.0	$302.7	January 2028
90%	$241.1	$305.1	April 2028
95%	$242.4	$308.5	June 2028

Table 8 – Option 2 - Summary of Probability Distributions for Overall Cost and Schedule – Post Response

As Table 7 indicates, completion of the project could extend out to June 2028, if not longer. Based on the above information, there is 70% confidence level that the project could be delivered by August 2027 with a cost of $327.7 million for Option 1 and $297.9 for Option 2 in year of expenditure dollars.

4.3 Significant Risks, Uncertainties and Strategies

Cost Risks

The tornado tables in Figures 13 and 14 show the potential impacts of the top ten post-response cost risks for the project and each alternative option. Additional information about the risks is provided in Appendix C – Risk Register. The risk names are listed on the vertical axis with expected cost impact identified. Risks in the tornado diagram are ranked in descending order showing the greatest risk to cost on top.

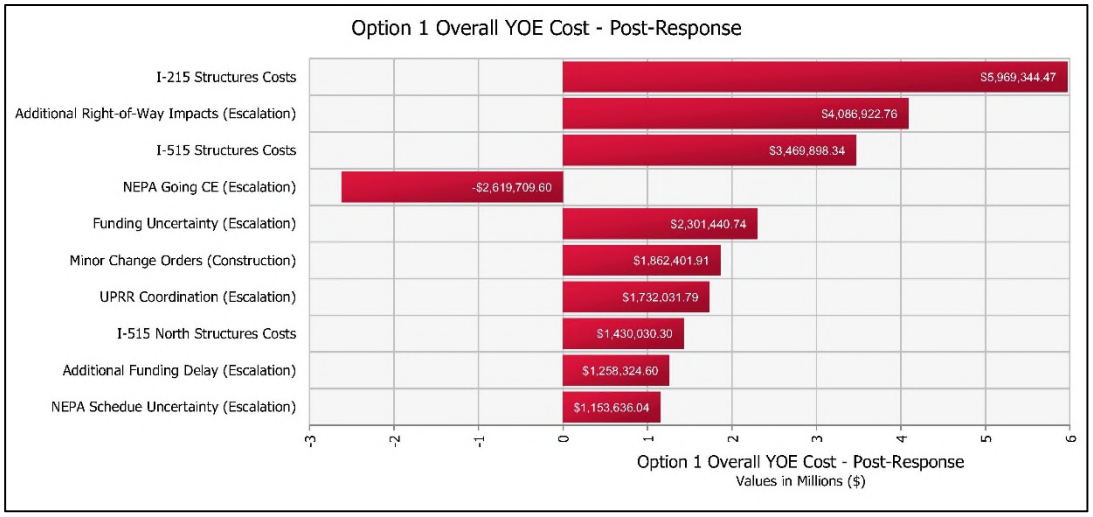


Figure 13 – Option 1 Post Response Cost Tornado Diagram

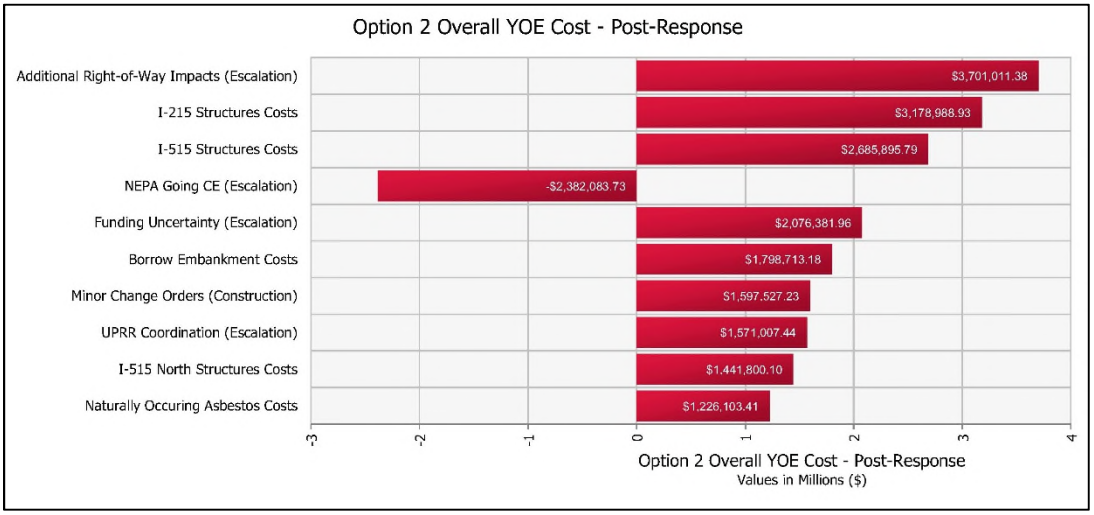


Figure 14 – Option 2 Post Response Cost Tornado Diagram

Schedule Risks

The tornado table in Figure 15 shows the potential impacts of the top ten post-response schedule risks for the project. Additional information about the risks is provided in Appendix C – Risk Register. The risk names are listed on the vertical axis with expected schedule impact identified. Risks in the tornado diagram are ranked in descending order showing the greatest risk to schedule on top.

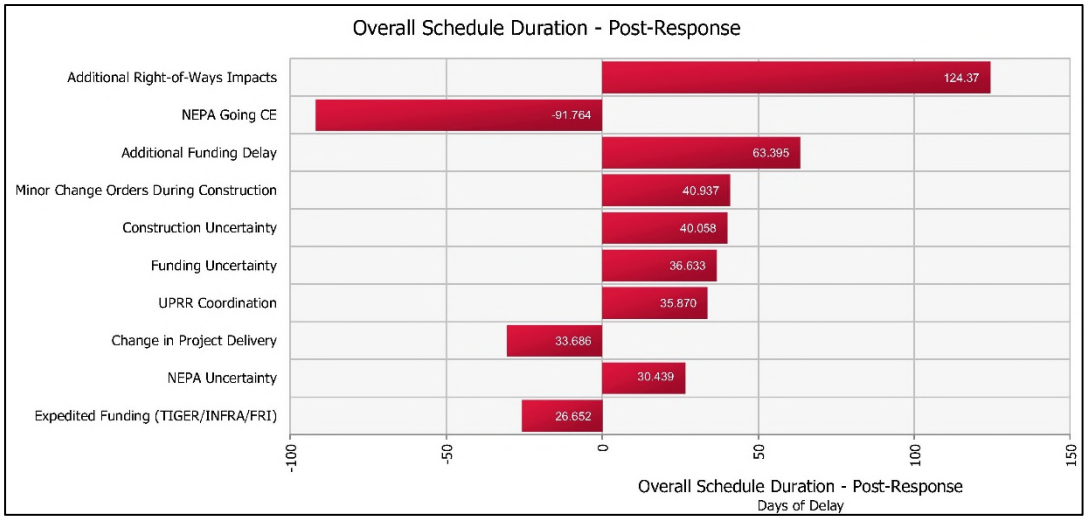


Figure 15 – Schedule Post Response Cost Tornado Diagram

Based on Figures 13 thru 15 it is very evident several key factors need to be addressed as the project moves forward. These factors and key strategies/action items include:

- Funding: Funding needs to be secured with a more confident time schedule of when the funding would be available. This primarily applies to construction funding.
- Bridge costs: As the project progresses structural design and associated structure construction costs should be more refined to reduce uncertainty in the project costs.
- Type of NEPA document: In early 2020, NDOT will assume preparing the NEPA document for the project. There is some uncertainty around the class of NEPA document required (i.e. Categorical Exclusion or Environmental Assessment). The current model show an opportunity for a Categorical Exclusion which could provide a significant reduction in time for the project.

5.0 CLOSING

Based on the results of discussions during the Risk Assessment Workshop and this report, the following recommendations are made:

1. When possible, based on the above described uncertainties, it is best to provide project costs and durations in a range based on the mid-80 percentile confidence level as shown in Table 6 to help manage stakeholder expectations.
2. Recognize and communicate that this report is a snapshot into the project at the time of the Risk Assessment Workshop. As the project progresses various uncertainties will be retired, while new uncertainties may surface. In general, as time moves on the range between various confidence levels should diminish. The City and NDOT should consider updates to the risk-based estimate at various milestones including preliminary and intermediate design submittals.
3. Utilize the 70th percentile confidence level estimates to help establish reasonable budgets and schedules and then strive through risk management strategies identified in the risk register to bring the project in under budget and schedule.
4. Implement the strategies discussed in Section 4.3 to reduce the uncertainties in the top threats and opportunities. As the risks are retired or mitigated, update the risk-based estimate to identify the next 5-10 risks that the project team should focus on. By focusing resources on the most significant risks the project team will be able to efficiently retire those risks and reduce the mid-80 percentile confidence range.
5. Continue progressing the project to identify a preferred option and begin design refinement to provide a more detailed cost estimate and funding plan which will help retire some of the primary risk elements and also identify any new risk items.

These results are intended to provide the City and the Project Team with the information needed to aid in making educated decisions about the project scope, schedule and budget. In addition, this report should aid in developing risk management strategies to ensure a successful project is developed and implemented within publicized schedules and budgets.

APPENDIX A

Base Cost Estimate

I-515/215 Henderson System Interchange - Option 1

Item	Quantity or Pecentage					Current Year Unit Cost					Current Year Base Total Cost	70% Base Cost Estimate
	(Low) Under (%)		Base		(%) Over (High)	(Low) Under (%)		Base		(%) Over (High)		
ROADWAY												
I-515			1			$13,843,091	-5.00%	$14,571,675	15.00%	$16,757,426	$14,571,675	$15,072,965
I-515 North			1			$6,602,280	-5.00%	$6,949,768	15.00%	$7,992,233	$6,949,768	$7,188,851.43
I-215			1			$10,971,004	-5.00%	$11,548,425.00	15.00%	$13,280,689	$11,548,425	$11,945,709.78
Lake Mead Parkway			1			$1,468,994	-5.00%	$1,546,309	15.00%	$1,778,255	$1,546,309	$1,599,504.57
Demolition - I-515			1			$8,377,782	-5.00%	$8,818,718	15.00%	$10,141,526	$8,818,718	$9,122,096.37
Demolition - I-515 North			1			$183,720	-5.00%	$193,389	15.00%	$222,397	$193,389	$200,041.90
Demolition - I-215			1			$233,734	-5.00%	$246,036	15.00%	$282,941	$246,036	$254,500.04
Demolition - Lake Mead Parkway			1			$72,200	-5.00%	$76,000	15.00%	$87,400	$76,000	$78,614.52
										Roadway Subtotal	$43,950,320	$45,462,283
STRUCTURES												
Bridges												
I-515			1			$29,061,184	-25.00%	$38,748,245	5.00%	$40,685,657	$38,748,245	$38,767,373.24
I-515 North			1			$12,721,642	-25.00%	$16,962,189	5.00%	$17,810,298	$16,962,189	$16,970,562.46
I-215			1			$49,186,219	-25.00%	$65,581,625	5.00%	$68,860,706	$65,581,625	$65,613,999.66
Lake Mead Parkway			1			$0	-25.00%	$0	5.00%	$0	$0	$0.00
Walls												
I-515			1			$1,902,500	0.00%	$1,902,500	10.00%	$2,092,750	$1,902,500	$1,943,212.91
I-515 North			1			$0	0.00%	$0	10.00%	$0	$0	$0.00
I-215			1			$3,506,272	0.00%	$3,506,272	10.00%	$3,856,899	$3,506,272	$3,581,305.14
Lake Mead Parkway			1			$0	0.00%	$0	10.00%	$0	$0	$0.00
										Structures Subtotal	$126,700,831	$126,876,453
TRAFFIC												
Traffic Signals												
I-515			0			$0	0.00%	$0	10.00%	$0	$0	$0.00
I-515 North			0			$0	0.00%	$0	10.00%	$0	$0	$0.00
I-215			0			$0	0.00%	$0	10.00%	$0	$0	$0.00
Lake Mead Parkway			1			$638,000	0.00%	$638,000	10.00%	$701,800	$638,000	$651,653.00
										Traffic Subtotal	$638,000	$651,653
UTILITIES												
Utilities			0			$0	0.00%	$0	0.00%	$0	$0	$0.00
										Utilities Subtotal	$0	$0
DRAINAGE												
Drainage												
I-515			1			$2,993,016	-3.00%	$3,085,583	25.00%	$3,856,979	$3,085,583	$3,257,611.06
I-515 North			1			$1,166,565	-3.00%	$1,202,644	25.00%	$1,503,305	$1,202,644	$1,269,694.06
I-215			1			$3,941,737	-3.00%	$4,063,646	25.00%	$5,079,558	$4,063,646	$4,290,203.23
Lake Mead Parkway			1			$108,723	-3.00%	$112,086	25.00%	$140,108	$112,086	$118,335.04
										Drainage Subtotal	$8,463,959	$8,935,843

Table A-1 - Option 1 Baseline Estimate

I-515/215 Henderson System Interchange - Option 1

Item	Quantity or Pecentage			Current Year Unit Cost			Current Year Base Total Cost	70% Base Cost Estimate
	(Low) Under (%)	Base	(%) Over (High)	(Low) Under (%)	Base	(%) Over (High)		
RISK SPECIFIC ITEMS								
Minor Change Orders		0		$3,595,062.20	$6,291,358.85	$8,987,655.50		$0
Naturally Occuring Asbestos		1		$100,000	$300,000	$500,000		$344,073
						Risk Specific Subtotal	$0	$7,229,596
Sub-Total Present Day Construction Cost							**$179,753,110**	**$189,155,829**
Landscaping and Aesthetics		3.0%			$5,392,593		$5,392,593	$5,674,675
Additional Items		10.0%			$17,128,915		$17,128,915	$18,915,583
Traffic Control		10.0%			$17,975,311		$17,975,311	$18,915,583
Roadside Safety		3.0%			$5,392,593		$5,392,593	$5,674,675
Erosion Control		0.5%			$898,766		$898,766	$945,779
					Sub-Total		$226,541,288	$239,282,124
Mobilization		7.0%			$15,857,890.18		$15,857,890	$16,749,749
Total Present Day Construction Cost							**$242,399,178**	**$256,031,873**
Preliminary Engineering & Final Design		4.0%			$9,695,967		$9,695,967	$7,566,233
Right-of-Way Engineering		1			$5,000		$5,000	$5,000.00
NEPA		0.2%			$484,798		$484,798	$378,312
Construction Engineering/Inspection		15.0%			$36,359,877		$36,359,877	$28,373,374
Administration		1.0%			$2,423,991.78		$2,423,992	$1,891,558
Legal		1.0%			$2,423,992		$2,423,992	$1,891,558
Total Present Day Construction and Engineering Cost							**$293,792,804**	**$296,137,909**
RIGHT-OF-WAY								
Rairoad Flagging		1		$250,000	$375,000	$375,000	$375,000	$366,394
						Right-of-Way Subtotal	$375,000	$366,394
Environmental Consideration		0.0%			$0		$0	$0.00
Overall Total Present Day Cost - Alternative 1							**$294,167,804**	**$289,985,172**

Note: No contingency is within the estimate since it is a baseline estimate.

Table A-1 - Option 1 Baseline Estimate

I-515/215 Henderson System Interchange - Option 2

Item	Quantity or Pecentage					Current Year Unit Cost					Current Year Base Total Cost	70% Base Cost Estimate
	(Low) Under (%)		Base		(%) Over (High)	(Low) Under (%)		Base		(%) Over (High)		
ROADWAY												
I-515			1			$16,215,273	-5.00%	$17,068,708	15.00%	$19,629,014	$17,068,708	$17,655,900
I-515 North			1			$4,578,931	-5.00%	$4,819,927	15.00%	$5,542,916	$4,819,927	$4,985,740.40
I-215			1			$17,391,806	-5.00%	$18,307,164	15.00%	$21,053,239	$18,307,164	$18,936,960.49
Lake Mead Parkway			1			$1,468,994	-5.00%	$1,546,309	15.00%	$1,778,255	$1,546,309	$1,599,504.57
Demolition - I-515			1			$9,897,309	-5.00%	$10,418,220	15.00%	$11,980,953	$10,418,220	$10,776,623.87
Demolition - I-515 North			1			$177,465	-5.00%	$186,805	15.00%	$214,826	$186,805	$193,231.40
Demolition - I-215			1			$1,843,072	-5.00%	$1,940,076	15.00%	$2,231,087	$1,940,076	$2,006,817.80
Demolition - Lake Mead Parkway			1			$72,200	-5.00%	$76,000	15.00%	$87,400	$76,000	$78,614.52
										Roadway Subtotal	$54,363,209	$56,233,393
STRUCTURES												
Bridges												
I-515			1			$22,754,108	-25.00%	$30,338,811	5.00%	$31,855,752	$30,338,811	$30,353,787.89
I-515 North			1			$11,638,219	-25.00%	$15,517,625	5.00%	$16,293,506	$15,517,625	$15,525,285.34
I-215			1			$26,505,848	-25.00%	$35,341,130	5.00%	$37,108,187	$35,341,130	$35,358,576.31
Lake Mead Parkway			1			$0	-25.00%	$0	5.00%	$0	$0	$0.00
Walls												
I-515			1			$3,790,821	0.00%	$3,790,821	10.00%	$4,169,903	$3,790,821	$3,871,943.40
I-515 North			1			$0	0.00%	$0	10.00%	$0	$0	$0.00
I-215			1			$12,062,361	0.00%	$12,062,361	10.00%	$13,268,597	$12,062,361	$12,320,491.80
Lake Mead Parkway			1			$0	0.00%	$0	10.00%	$0	$0	$0.00
										Structures Subtotal	$97,050,748	$97,430,085
TRAFFIC												
Traffic Signals												
I-515			0			$0	0.00%	$0	10.00%	$0	$0	$0.00
I-515 North			0			$0	0.00%	$0	10.00%	$0	$0	$0.00
I-215			0			$0	0.00%	$0	10.00%	$0	$0	$0.00
Lake Mead Parkway			1			$638,000	0.00%	$638,000	10.00%	$701,800	$638,000	$651,653.00
										Traffic Subtotal	$638,000	$651,653
UTILITIES												
Utilities			1			$500,000	0.00%	$500,000	0.00%	$500,000	$500,000	$500,000.00
										Utilities Subtotal	$500,000	$500,000
DRAINAGE												
Drainage												
I-515			1			$2,906,485	-3.00%	$2,996,376	25.00%	$3,745,470	$2,996,376	$3,163,430.57
I-515 North			1			$1,000,346	-3.00%	$1,031,285	25.00%	$1,289,106	$1,031,285	$1,088,781.41
I-215			1			$3,238,193	-3.00%	$3,338,343	25.00%	$4,172,929	$3,338,343	$3,524,462.99
Lake Mead Parkway			1			$108,723	-3.00%	$112,086	25.00%	$140,108	$112,086	$118,335.04
										Drainage Subtotal	$7,478,090	$0

Table A-2 - Option 2 Baseline Estimate

I-515/215 Henderson System Interchange - Option 2

Item	Quantity or Pecentage					Current Year Unit Cost					Current Year Base Total Cost	70% Base Cost Estimate
	(Low) Under (%)		Base		(%) Over (High)	(Low) Under (%)		Base		(%) Over (High)		
RISK SPECIFIC ITEMS												
Minor Change Orders			0			$3,200,600.94		$5,601,051.65		$8,001,502.35		$0
Borrow			1			$2,000,000.00		$5,000,000.00		$7,500,000.00		$5,534,662
16" HP Gas Line Relocation			1			$400,000.00		$500,000.00		$600,000.00		$522,036
Naturally Occuring Asbestos			1			$1,000,000		$3,000,000		$5,000,000		$3,440,727
										Risk Specific Subtotal	$0	$15,627,448
Sub-Total Present Day Construction Cost											**$160,030,047**	**$170,442,578**
Landscaping and Aesthetics			3.0%					$4,800,901			$4,800,901	$5,113,277
Additional Items			10.0%			$14,492,436	-5.00%	$15,255,196	15.00%	$17,543,475	$15,255,196	$17,044,258
Traffic Control			10.0%					$16,003,005			$16,003,005	$17,044,258
Roadside Safety			3.0%					$4,800,901			$4,800,901	$5,113,277
Erosion Control			0.5%					$800,150			$800,150	$852,213
								Sub-Total			$201,690,200	$215,609,861
Mobilization			7.0%					$14,118,314.03			$14,118,314	$15,092,690
Total Present Day Construction Cost											**$215,808,514**	**$230,702,552**
Preliminary Engineering & Final Design			4.0%					$8,632,341			$8,632,341	$9,228,102
Right-of-Way Engineering			1					$5,000			$5,000	$5,000.00
NEPA			0.2%					$431,617			$431,617	$461,405
Construction Engineering/Inspection			15.0%					$32,371,277			$32,371,277	$34,605,383
Administration			1.0%					$2,158,085.14			$2,158,085	$2,307,026
Legal			1.0%					$2,158,085			$2,158,085	$2,307,026
Total Present Day Construction and Engineering Cost											**$261,564,920**	**$279,616,492**
RIGHT-OF-WAY												
Rairoad Flagging			1			$250,000		$375,000		$375,000	$375,000	$366,394
										Right-of-Way Subtotal	$375,000	$366,394
Environmental Consideration			0.0%					$0			$0	$0.00
Overall Total Present Day Cost - Alternative 1											**$261,939,920**	**$281,747,873**

Note: No contingency is within the estimate since it is a baseline estimate.

Table A-2 - Option 2 Baseline Estimate

APPENDIX B
Workshop Baseline Flow Chart

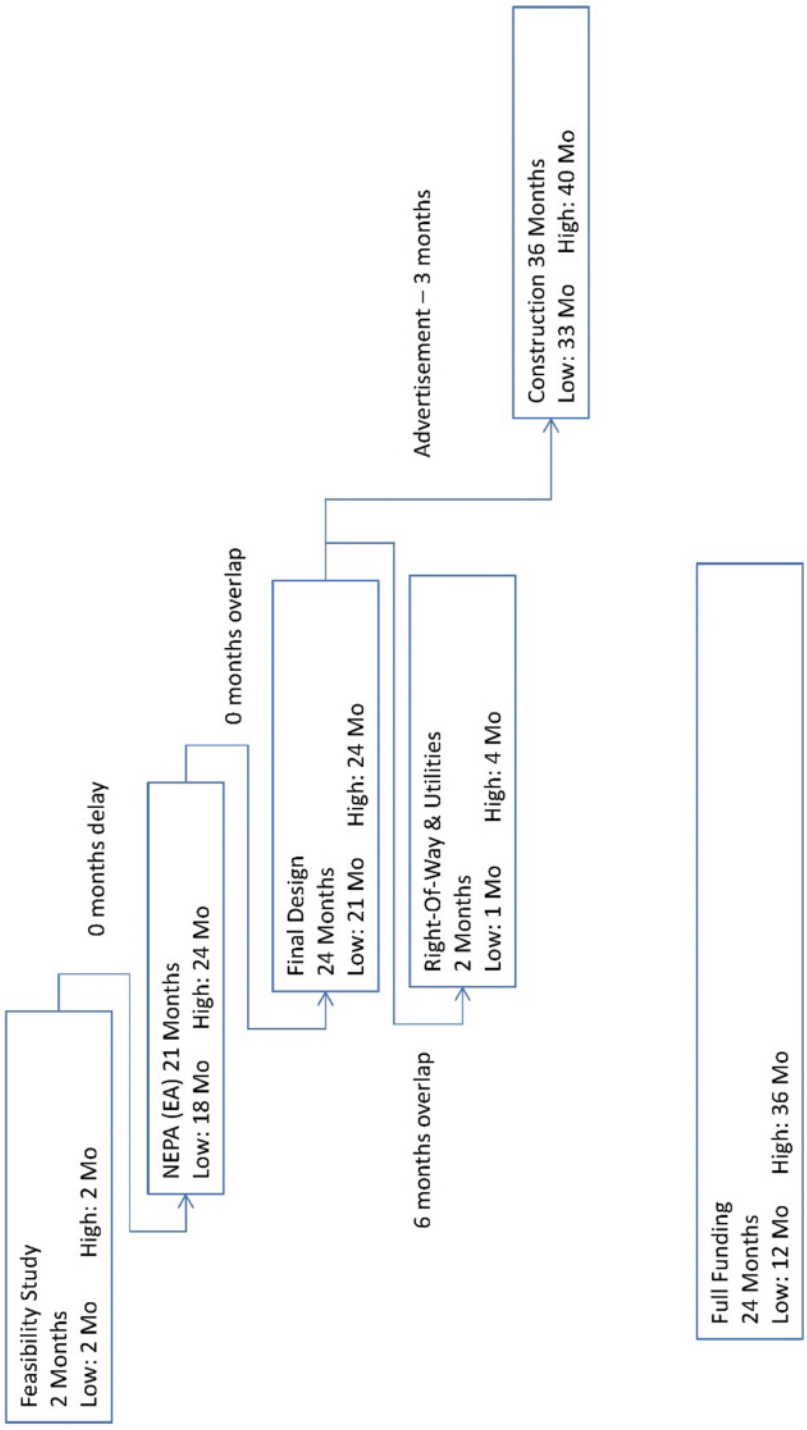


Figure B-1 –Baseline Flow Chart

APPENDIX C
Risk Register

Threat/Opportunity	Description	Status	Strategy	Option 1 - Pre-Response							Option 2 - Pre-Response							Option 1 - Post Response							Option 2 - Post Response							Notes
				Likelihood	Cost Impact			Schedule Impact			Likelihood	Cost Impact			Schedule Impact			Likelihood	Cost Impact			Schedule Impact			Likelihood	Cost Impact			Schedule Impact			
					Low	Most Likely	High	Low	Most Likely	High		Low	Most Likely	High	Low	Most Likely	High		Low	Most Likely	High	Low	Most Likely	High		Low	Most Likely	High	Low	Most Likely	High	
CONSTRUCTION																																
Other Large Events in the Area		Active	Accept	10%				0.5 MO	1 MO	2 MO	Same							10%				0.5 MO	1 MO	2 MO	Same							Minor Impacts
Strucure Costs	$240 for steel bridge + cost of retaining walls associated with the bridge. $175 for widening concrete bridge. New build $150 for concrete. Flyover bridges with high falsework were coded as steel bridges ($240). Centennial had large flyovers.	Active	Exploit		150	170/sqft	190																									
Structures Cost	Double DDI cross-overs. Consevative on bridge quantity. (base price $150/sqft). Maybe $25/sf high. (Alternative 3 only)	Active									100%	-20 SF	-$25 SF	-$30 SF																		
Differing Site Conditions	Low risk as just expanding upon an existing interchange and foundations. Don't expect any surprises.	Inactive	Monitor																													
Alternative 3 requires 500k CUYDs for borrow.	Will need to identify source with R45 material.	Active									50%	$2 Mil	$5 Mil	$7.5 Mil																		
Minor Change Orders	This risk accounts for 0.5%-2% of the total project costs to be used for minor change orders and unknown unknowns during construction.	Active	Accept	90%	2%	3.50%	5%				Same				2MO	3MO	4MO	25%	2%	3.50%	5%	2MO	3MO	4MO	Same							
CONTRACTING AND PROCUREMENT																																
Project Delivery Method	Based on UPRR coordnination time frame would be limited. Could be DB/CMAR	Active	Mitigate	50%				-1 MO	-2 MO	-3 MO	Same																					This is being reviewed as part of the on-going project.
Wizard Estimation	Wizard utilitizes percentages which can raise a higher base cost than actual needed. Project is at the planning level design.	Active	Mitigate																													Utilizing Wizard uncertainty amounts in cost uncertainty.
Delays in Completion	Risk would be minimal since D-B-B, would not advertise until r/w and utility issues taken care of.	Inactive	Monitor	25%					1MO		Same																					
DESIGN/PS&E																																
Phasing of Project	This risk was accounted for in the funding risk which accounts for receiving all funding in one pot.	Inactive																														
Changes to Design Standards	Design standard changes are not anticipated at this time.	Inactive	Monitor																													
Scope Definition and Future Scope Changes	No anticipated changes to scope. Model accounts for the County's Stephanie to Pecos project.	Inactive	Monitor																													
Future Coordination with Possible I-11 Alignment	Project was reviewed for impacts from I-11 and the conclusion was no. NDOT may analyze as part fo the I-11 project. Continue to monitor but inactive for now.	Inactive	Monitor																													
Value Engineering for Design of Smaller Structures	Potential to reduce unit costs.	Active	Exploit																													This will be need to be addressed as alternatives are finalized and decided upon.
Preliminary Engineering/Scoping takes longer than expected.		Inactive																														
Environmental and Hydraulics																																
Environmental Assessment (EA)	EA. Potential change it could go to CE	Active	Accept	25%				-9 MO	-10.5 MO	-12 MO	Same																					
Delay in Alternative indecision	Potential indecision on a selected alternative	Active	Accept	50%				0 MO	1.5 MO	3 MO																						At 3 months maximum, this could be absorbed into EA schedule float. If extends past 3 months would be an issue.
Nesting birds may delay construction	Risk of migratory birds nesting delaying start of bridge demolition or construction activities	Inactive	Monitor																													
Hazardous Materials discovered during excavation	Not a NEPA concern. Existing consolidation may be of concen. REVISIT IN CONST. COST	Inactive	Monitor																													
Arch. Discoveries during construction	Contractor excavation activities expose some form of cultural resources. EA currently states no mitigation anticipated at this time.	Inactive	Monitor																													
Regional Flood Control Facility	If channel is moved on west side 515, may require a CLOMR/LOMR by the City	Active	Accept								100%		$10k																			Insignficant to overall cost.
Naturally Occuring Asbestos and	Potential for NOA material within the project. Also includes unsuitable material possibly below surface.	Active	Mitigate	75%	$100k		$500k				75%	$1 Mil		$5 Mil																		

Figure C-1 - Risk Register

Threat/Opportunity	Description	Status	Strategy	Option 1 - Pre-Response							Option 2 - Pre-Response							Option 1 - Post Response							Option 2 - Post Response							Notes
				Likelihood	Cost Impact			Schedule Impact			Likelihood	Cost Impact			Schedule Impact			Likelihood	Cost Impact			Schedule Impact			Likelihood	Cost Impact			Schedule Impact			
					Low	Most Likely	High	Low	Most Likely	High		Low	Most Likely	High	Low	Most Likely	High		Low	Most Likely	High	Low	Most Likely	High		Low	Most Likely	High	Low	Most Likely	High	
Management/Funding																																
NEPA Contract Approval	Current schedule anticipates going to Board meeting in March. May not be until April.	Active	Accept	50%				1 M	1 MO	3 MO	Same				1 M	1 MO	3 MO															
TIGER/INFRA/Recissions/FRI	Potential to obtain additional funds through TIGER/INFRA or recessions.	Active	Accept	20%				1 YR	1 YR	1 YR	Same																					
Funding	Project would not be programmed until NEPA is cleared. Bonding may be required and project will need to compete with statewide priorities.	Active	Accept	50%				1 YR	2 YR	3 YR	Same				1 YR	2 YR	3 YR															
RIGHT-OF-WAY																																
Additional ROW needs.	Current design avoid right-of-way impacts as currently laid out.	Active	Monitor	15%				9MO	18MO	24MO	Same																					
RAILROAD																																
UPRR Coordination Delays Construction Start	UPRR will need to provide approval. Maybe a private property owner under the north 515 crossing.	Active	Accept	50%				0 MO	3 MO	6 MO	Same																					
Railroad Flagging	Risk is that base does not include railroad flagging costs.	Active	Accept	100%	$250k	$375k	$500k				Same																					
STRUCTURES AND GEOTECH																																
UTILITIES																																
Utility Relocation/Coordination between Phases		Inactive																														
Utility Relocations	Potential SW Gas Relocation. 16" HP line	Active	Accept								100%	$400k	$500k	$600k	1 MO	2 MO	4 MO															

Figure C-1 - Risk Register

APPENDIX D
Additional Model Output

NDOT Risk Breakdown Structure Category	I-215/I-515 Interchange Risk Count			
	Active	Inactive	Retired	Total
Environmental & Hydraulics	4	3	0	7
Right-of-Way	1	0	0	1
Utilities	1	1	0	2
Design/PS&E	1	5	0	6
Structure & Geotech	0	0	0	0
Management/Funding	3	0	0	3
Contracting & Procurement	2	1	0	3
Construction	4	1	0	5
Railroad	2	0	0	2
Total	**18**	**11**	**0**	**29**

Table D-1 – I-215/I-515 Interchange Risk Count Detail