HENDERSON INTERCHANGE

HENDERSON INTERCHANGE COST RISK ASSESSMENT

September 2021

NEVADA DOT SAFE AND CONNECTED

An Employee Owned Company CA Group, Inc

Prepared For:

Nevada Department of Transportation

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I. EXECUTIVE SUMMARY

The attached Cost Risk Assessment (CRA) report for the Nevada Department of Transportation's (NDOT) proposed improvements to the Henderson Interchange (Interstate 215 (I-215), Interstate 515 (I-515), and Interstate 11 (I-11) system interchange) identifies project threats and opportunities that could have an effect on project cost and/or budget.

In preparing this 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 CRA utilized initial risks identified in the CRA conducted in November 2019. Risks and base costs were updated and evaluated for the preferred NEPA alternative to provide a cost and schedule validation.

The following tables present results from the June 2021 CRA and are intended as a quick summary for NDOT Executive Leadership Team (ELT) and management.

Risk-Adjusted Cost Results (in Millions – YOE $'s)				
Scenario	Base Cost	Cost Range		
		10th Percentile	70th Percentile	90th Percentile
Pre-Response	$279.3	$304.9	$359.4	$410.9
Post-Response		$294.7	$330.6	$345.4

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	May 2028	June 2029	November 2029
Post-Response		January 2028	February 2029	July 2029

Table E-2 – Risk Adjusted Project Completion Date

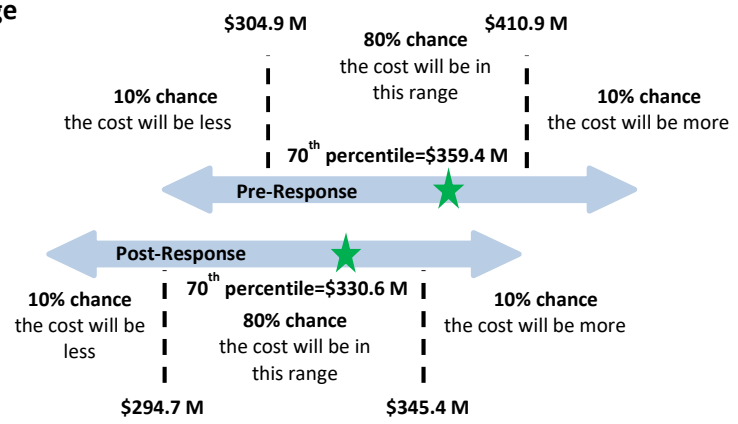
Figure E-1 on the attached page presents a one-page snapshot of I-215/I-515 Henderson Interchange project with respect to overall benefits, costs and schedule.

Project Summary	I-215/I-515 Henderson Interchange June 2021	NEVADA DOT

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

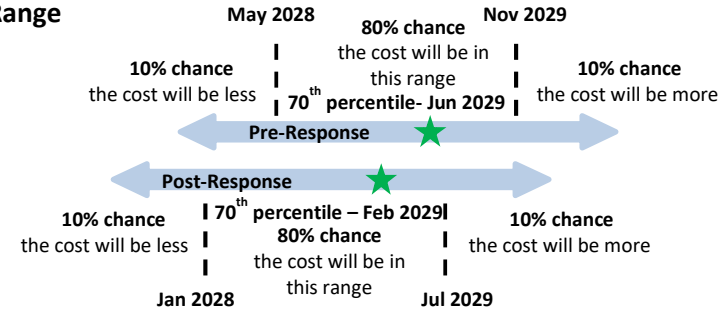
CRA Cost Range



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	June 2021

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 Nevada Department of Transportation's (NDOT) proposed improvements to the Henderson Interchange (Interstate 215 (I-215), Interstate 515 (I-515), and Interstate 11 (I-11) system interchange). The CRA utilized initial risks identified in a CRA conducted in November 2019. Risks and base costs were updated and evaluated for the preferred NEPA alternative to provide a cost and schedule validation. A build alternative has been identified that will provide improvements to the interchange and adjacent roadways that will enhance interchange operations, capacity, and safety. This alternative is currently being reviewed for any potential environmental impacts and overall benefits. The following study documents the Risk Assessment Workshop that was conducted by CA Group on June 8th and 9t, 2021.

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 the preferred alternative;
- Identify any significant risks or opportunities unique to the preferred alternative; and
- Identify and prioritize key cost and schedule risks and opportunities for the proposed alternative.

The workshop and subsequent statistical analysis followed an approach very similar to the Washington State Department of Transportation's Cost Estimate Validation process (CEVP®), FHWA Cost Estimate Review (CER) 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 are 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
- Lynnette Russell – NDOT Project Management
- David Bowers – NDOT Project Management
- Marty Strganac – NDOT District 1
- Mario Gomez – NDOT District 1
- Ray Enerio – NDOT Hydraulics
- Eric Yount – NDOT Hydraulics
- Nate Harrison – NDOT Structures
- Jesse Smithson – NDOT Roadway
- Kim Diegle – NDOT Roadway
- Jim Caviola – CA Group
- Jim Mischler – CA Group
- Andrea Engelman – CA Group
- Valerie Flock – CA Group

- Tammy Michels – CA Group

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

2. PROJECT DESCRIPTION AND ASSUMPTIONS

2.1. Project Scope and Phasing

The existing system interchange between I-215 and I-515 was constructed between 2004 and 2006 when the population of the Las Vegas Valley was approximately 1.5 million people. The population has since increased by about 50% and is projected to continue to increase. Traffic volumes at the interchange exceed the original design year forecasts. Additionally, a service interchange was constructed at I-215/Gibson Road close to the system interchange creating eastbound (EB) weaving conflicts between vehicles entering at Gibson Road bound for Lake Mead Parkway and vehicles transitioning to the system interchange ramps.

A combination of the following critical needs demonstrates why improvements must be considered for the Henderson Interchange:

- Roadway deficiencies will continue to contribute to congestion and travel delays.
- Existing congestion will worsen with projected increases in passenger vehicles, trucks, and public transit vehicles along I-515, I-215, and I-11.
- Surrounding roadways connectivity needs to be restored to increase safety.
- Traffic safety will further degrade as higher crash rates are experienced in and around the Henderson Interchange.

The purpose of the proposed project is to:

- Resolve existing roadway deficiencies in the Henderson Interchange and surrounding roadways.
- Provide transportation improvements to serve existing and future growth areas.
- Restore local traffic connectivity.
- Accommodate regional and local plans.

The Build Alternative is a crossover style interchange with the east-west highway directions crossing each other at special grade separation structures east and west of the central interchange. By crossing the traffic similar to the diverging diamond interchange on Horizon Drive at I-11, motorists would be positioned to freely enter and exit on the side that is in the direction they are intending to travel, and this negates the need for most of the large 'flyover' bridge structures commonly associated with a directional interchange. The Build Alternative would use 22 of the existing 27 bridges in the project area, demolishing the four existing flyover bridges and a smaller bridge that is no longer needed with the new configuration. Eleven new bridges would be constructed with the Build Alternative.

The Build Alternative includes the following major components:

- Crossover style interchange for the east-west highway directions,
- Reconnection of travel from Lake Mead Parkway to Gibson Road using braided ramps,
- Travel between I-215 and Auto Show Drive using braided ramps,
- Re-use of 22 out of the 27 existing bridges in the project area,

- Built-in capacity to add a future lane in each direction between I-215 and I-515, either as general purpose or HOV lanes,
- Auxiliary lanes on I-11 between Horizon Drive and the system interchange, and
- Arterial street improvements on Lake Mead Parkway east of the system interchange to Van Wagenen.

Figure 1: Henderson Interchange Project Limits

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 is anticipated to be available by 2024. While not fully documented, Fuel Revenue Indexing allotted to Southern Nevada could fulfill any gaps.
- Design
  - Design Level
    - Design for the project is currently at 15-20%
    - Design is in the early preliminary design and NEPA phase. Changes in design could occur due to public and stakeholder feedback.
  - Landscaping
    - Budget of 3% of construction. No 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 is currently in the NEPA evaluation process.
- Permitting
  - No significant environmental permits are anticipated (excluding USACOE 404).
  - Contractor will obtain necessary construction permits.
- Right-of-Way
  - No permanent right-of-way acquisitions are anticipated.
- Utilities
  - No significant utility impacts anticipated since improvements are being done within right-of-way.
- Other Stakeholders
  - City of Henderson (COH)
  - Clark County
  - Regional Transportation Commission of Southern Nevada (RTC)
  - Adjacent business and property owners
- Procurement
  - Delivery Method
    - One phase of design-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 NDOT and 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 monitoring risks. The difference in costs of the two strategies helps NDOT develop a cost/benefit of the level effort that should applied to mitigating and monitoring risks 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 the NDOT Executive Leadership Team (ELT) 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 it is still in the early phases of development requiring some items to be excluded. For this analysis significant exclusions are listed below.

- 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

CA Group used NDOT's Wizard cost estimation program to develop a base cost estimate. 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. **Table 1** provides a summary of the base cost estimate. It should be noted, that since this is a base estimate, no contingencies were added.

Description	Baseline Cost
Roadway	$59,475,964
Structures	$91,401,631
Traffic	$1,000,000
Drainage	$754,800
Utilities	$250,000
Additional Items	$15,263,240
Bid Item Subtotal	**$168,145,635**
Landscaping and Aesthetics (3%)	$5,044,369
Traffic Control (10%)	$16,814,563
Roadside Safety (3%)	$5,044,369
Erosion Control (0.5%)	$840,728
Subtotal	$195,889,664
Mobilization (7%)	$13,712,277
Contract Total	**$209,601,941**
Preliminary & Final Engineering (6%)	$12,576,116
R/W Engineering	$209,602
Construction Engineering (7%)	$14,672,137
Administration (1%)	$2,096,019
Legal (1%)	$2,096,019
Subtotal	$241,251,834
Right-of-Way Acquisition	$50,000
Environmental Considerations (0%)	$0
Project Total (Base Cost)	**$241,301,834**

Table 1 –Overall Base Cost Estimate Summary (2021 Dollars)

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

Uncertainty

A cost estimate is a "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 and other 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, other factors may play into uncertainty such as available geotechnical information, NEPA constraints, right-of-way, and type of project delivery. **Table 2** shows the Base Project Cost Uncertainty by key project components.

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	$12,010,193	$12,576,116	$13,918,903
R/W Engineering	$200,170	$209,602	$231,982
Construction Engineering	$14,011,892	$14,672,137	$16,238,720
Administration	$2,001,699	$2,096,019	$2,319,817
Legal	$2,001,699	$2,096,019	$2,319,817
Right of Way Acquisition	$50,000	$50,000	$50,000
Environmental Considerations	$0	$0	$0
Construction	$200,169,891	$209,601,941	$231,981,708
Total	**$230,445,544**	**$241,301,834**	**$267,060,947**

Table 2 –Base Cost Uncertainty by Activity

Escalation Rates

Escalation rates are a measurement of change 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 3**.

Year	Engineering			Right-of-Way			Construction		
	10%	50% (Median)	90%	10%	50% (Median)	90%	10%	50% (Median)	90%
2019	1.15%	1.15%	1.15%	4.75%	4.75%	4.75%	-0.47%	-0.47%	-0.47%
2020	-0.05%	1.23%	2.52%	-3.11%	1.81%	6.72%	-4.85%	0.03%	4.91%
2021	-0.06%	1.73%	4.00%	-3.69%	2.64%	9.81%	-3.11%	1.95%	8.46%
2022	0.19%	2.46%	4.72%	-4.80%	3.19%	11.59%	-1.40%	4.00%	10.16%
2023	0.61%	2.70%	4.76%	-4.33%	4.12%	12.62%	-1.30%	3.82%	9.51%
2024	0.66%	2.68%	4.76%	-4.16%	4.23%	12.57%	-1.50%	3.31%	8.74%
2025	0.40%	2.44%	4.46%	-4.28%	4.31%	12.90%	-1.78%	3.07%	8.45%
2026	0.11%	2.23%	4.29%	-4.42%	4.52%	13.70%	-2.38%	2.87%	8.84%
2027	-0.02%	2.16%	4.35%	-3.26%	5.37%	13.99%	-2.38%	2.82%	8.83%
2028+	-0.08%	2.21%	4.50%	-4.28%	4.31%	12.90%	-3.06%	2.81%	9.50%
Average	---	**2.21%**	---	---	**3.83%**	---	---	**2.74%**	---

Table 2 – 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 impacts onto 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. 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 inherent opportunity in implementing risk management strategies: as the project progresses and risks are retired, the risk-based estimate standard deviation will decrease, and thereby, will reduce the seventy-percentile cost and increasing confidence level.

Probability distributions for total overall project cost pre-response (current year dollars) are shown in **Figure 2** in probability mass functions (PMFs) and cumulative distribution functions (CDFs) format. These probability distributions reflect the base cost combined with identified project risks and opportunities

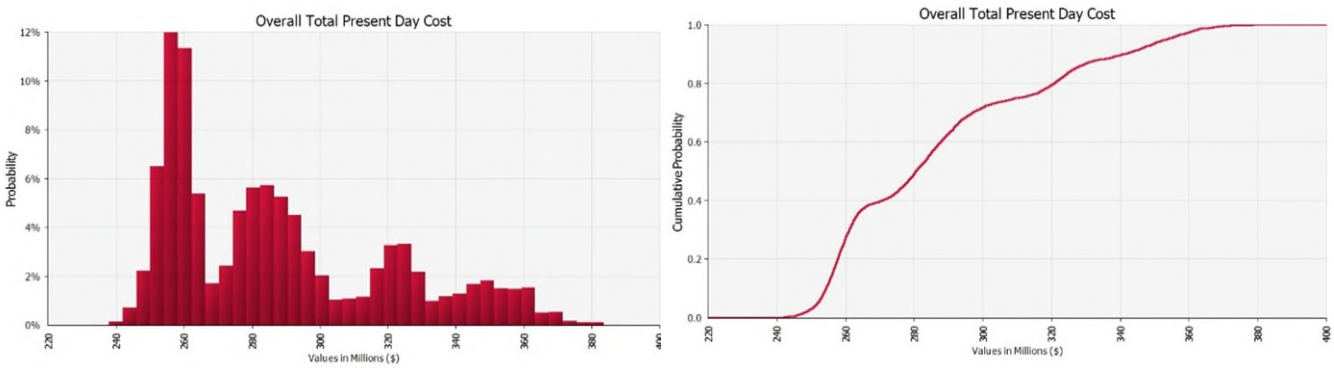


Figure 2 Probability Distribution for Overall Total Present Day Cost ($2021) – Pre-Response, presented in two ways: a) probability mass function (PMF); b) cumulative distribution function (CDF)

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 2**, the most likely overall project cost in 2021 dollars will be approximately $256.3 million. **Figure 3** provides the same information in year of expenditure dollars with a most likely overall project cost of approximately $308.8 million. Year of expenditure costs are calculated from an anticipated pre-response risk-based schedule which is shown in **Figure 4**. **Figure 4** anticipates the most likely completion to be February 2029 based on pre-response activities.

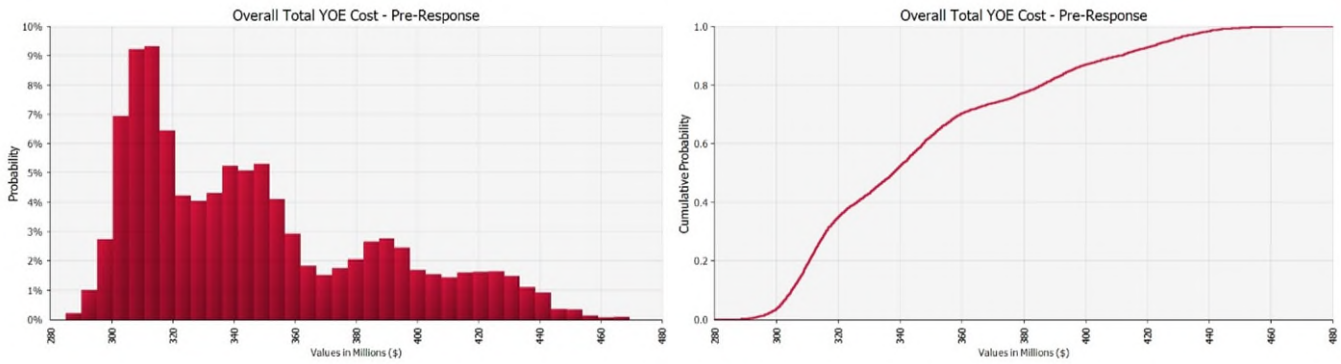


Figure 3 Probability Distribution for Overall Total Year of Expenditure Cost – Pre-Response, presented in two ways: a) probability mass function (PMF); b) cumulative distribution function (CDF)

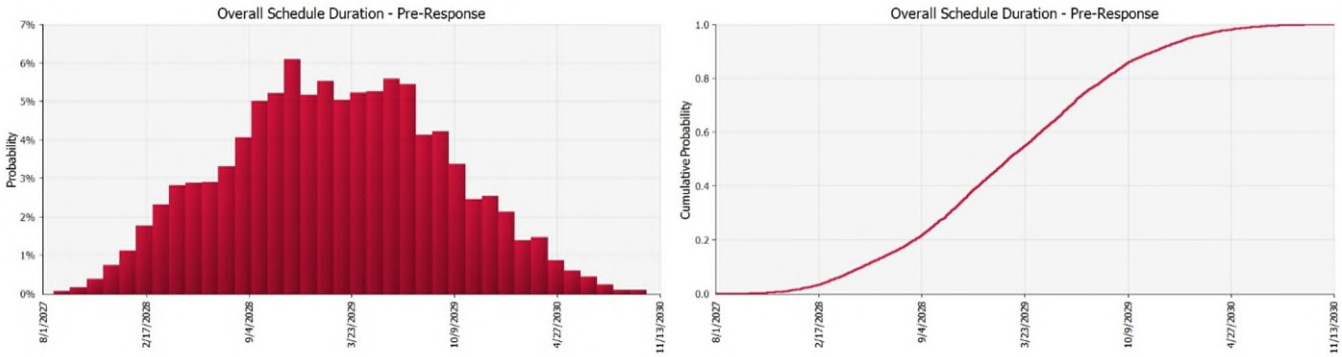


Figure 4 Probability Distribution for Overall Schedule Duration – Pre-Response, presented in two ways: a) probability mass function (PMF); b) cumulative distribution function (CDF)

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 2**, 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 $359.4 million in 2021 dollars.

4.3 Post-Response Results

Sound project management execution consists of the agencies and those involved proactively managing risks and opportunities to reduce potential increases in 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 5**, **6**, **7**.

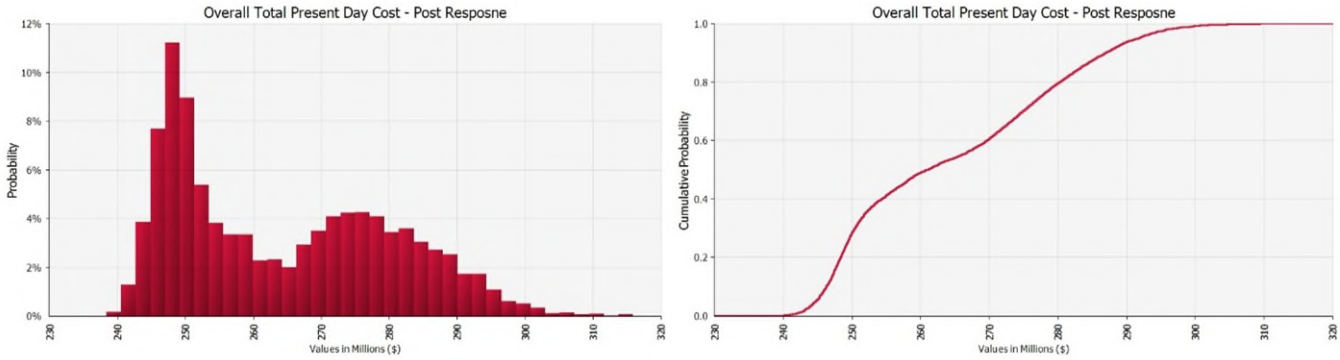


Figure 5: Probability Distribution for Overall Total Present Day Cost ($2021) – Post-Response, presented in two ways: a) probability mass function (PMF); b) cumulative distribution function (CDF)

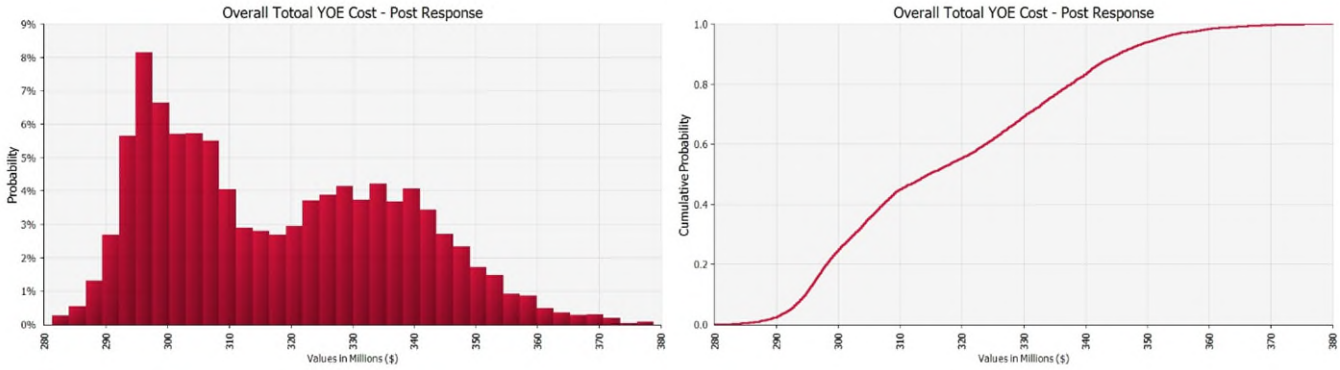


Figure 6: Probability Distribution for Overall Total Year of Expenditure Cost – Post-Response, presented in two ways: a) probability mass function (PMF); b) cumulative distribution function (CDF)

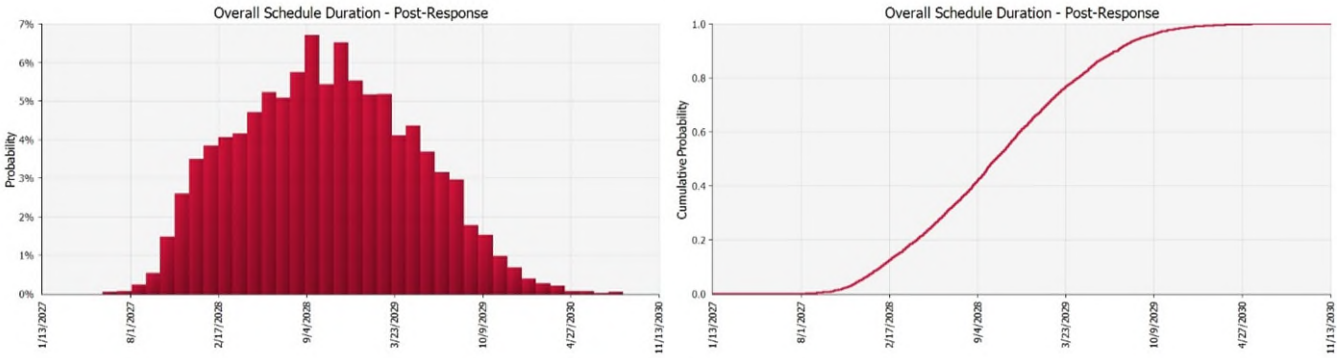


Figure 7 Probability Distribution for Overall Schedule Duration – Post-Response, presented in two ways: a) probability mass function (PMF); b) cumulative distribution function (CDF)

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 $249.0 million in 2021 dollars or $297.2 million in year of expenditure with an anticipated completion of September 2028.

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 4** provides a summary of the mid-80 percent confidence level range post-response.

Description	10th Percentile (Lower Limit)	90th Percentile (Upper Limit)
Total Project Cost (2021 Dollars)	$246.3 million	$286.9 million
Total Project Cost (YOE Dollars)	$294.7 million	$345.4 million
Project Completion Date	January 2028	July 2029

Table 4 – Mid-80 Percent Confidence Level Range for the Overall Project Post-Response

Table 5 provides a summary of various post-response probability distributions (e.g., confidence levels) for the overall project including current year cost, year of expenditure, and project duration.

	Total Project Cost (2021$ Mil)	Total Project Cost (YOE $ Mil)	Overall Completion Date
Base	$241.3	$279.3	July 2023
Mean	$264.2	$317.9	October 2028
Standard Dev.	$16.0	$19.9	198 Days
5%	$244.7	$292.3	December 2027
10%	$246.3	$294.7	January 2028
15%	$247.4	$296.4	March 2028
20%	$248.3	$298.1	April 2028
25%	$249.3	$300.1	May 2028
30%	$250.4	$302.6	June 2028
35%	$251.9	$304.8	July 2028
40%	$254.4	$307.3	August 2028
45%	$257.5	$310.2	September 2028
50%	$261.1	$314.6	August 2028
55%	$265.9	$319.7	November 2028
60%	$269.7	$323.8	December 2028
65%	$272.4	$327.3	January 2029
70%	$274.9	$330.6	February 2029
75%	$277.4	$334.0	March 2029
80%	$280.3	$337.6	April 2029
85%	$283.4	$341.0	May 2029
90%	$286.9	$345.4	July 2029
95%	$291.8	$363.8	September 2029

Table 5 – Summary of Probability Distributions for Overall Cost and Schedule – Post Response

As **Table 5** indicates, completion of the project could extend out to September 2029, if not longer. Based on the above information, there is 70% confidence level that the project could be delivered by February 2029 with a cost of $330.6 million.

4.3 Significant Risks, Uncertainties and Strategies

Cost Risks

The tornado table in **Figure 8** shows the potential impacts of the top ten post-response cost 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 the expected cost impact identified. Risks in the tornado diagram are ranked in descending order showing the greatest risk to the cost on top.

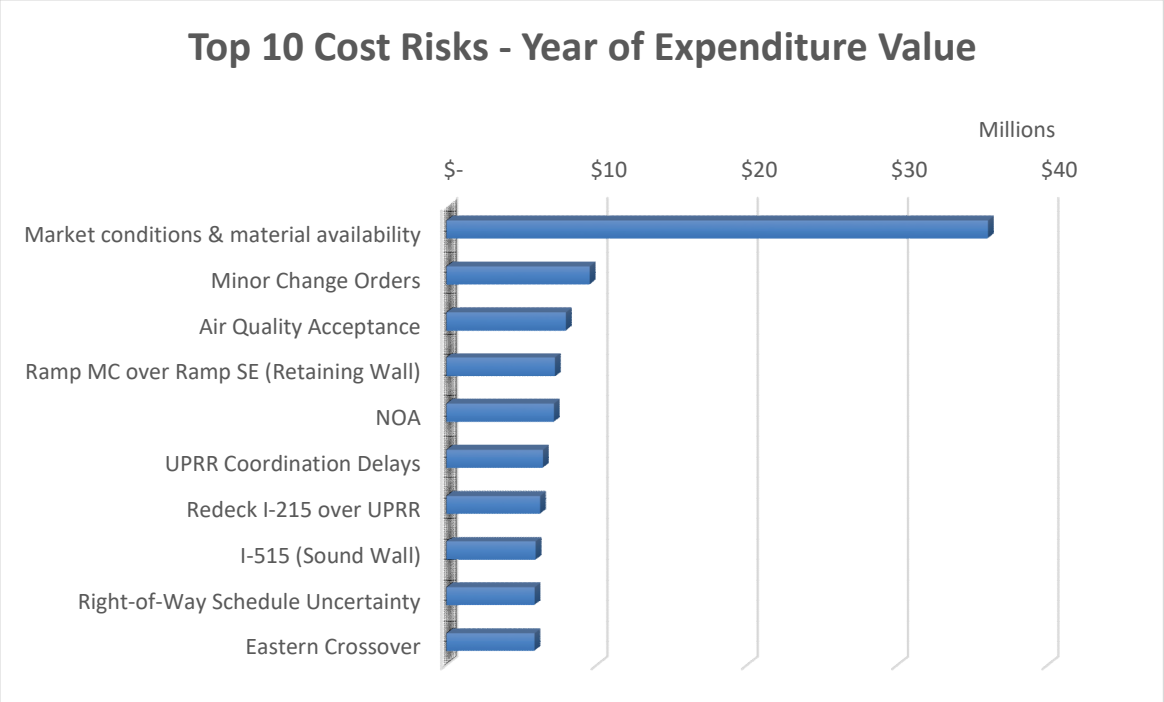


Figure 8 Post Response Cost Tornado Diagram

Schedule Risks

The tornado table in **Figure 9** 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 the expected schedule impact identified. Risks in the tornado diagram are ranked in descending order showing the greatest risk to the schedule on top.

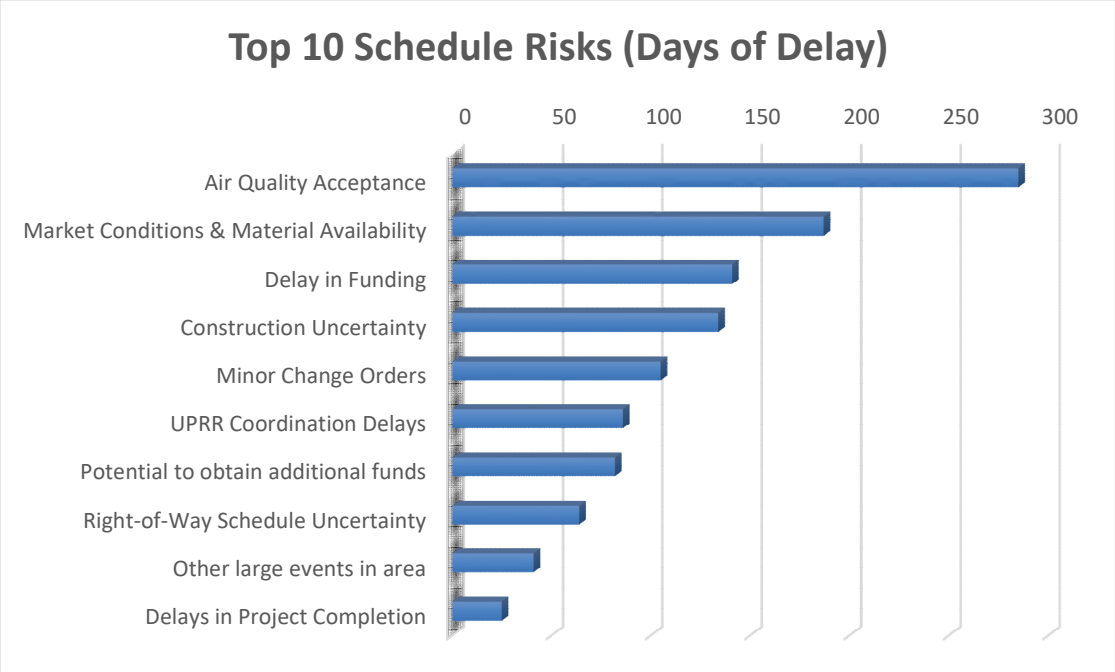


Figure 9 Post Response Schedule Tornado Diagram

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 2**) 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. 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 five to ten 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. By implementing a proactive risk management plan, it is safe to assume that NDOT will be able to reduce the 70th percentile project cost by approximately $66 million and reduced the project duration by approximately four months.

These results are intended to provide NDOT 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 - Improved Option 2A

Item	Quantity or Percentage					Unit	Current Year Unit Cost					Current Year Base Total Cost	70% Base Cost Estimate
	(Low) Under (%)		Base	(%) Over (High)			(Low) Under (%)		Base	(%) Over (High)			
ROADWAY													
New Asphalt Pavement Areas	1	0%	1	0%	1		$12,222,982	-5%	$12,866,297	15%	$14,796,242	$12,866,297	$13,308,919
New Concrete Pavement Areas	1	0%	1	0%	1		$15,009,433	-5%	$15,809,929	15%	$18,181,418	$15,809,929	$16,353,817
Widened Concrete Pavement Areas	1	0%	1	0%	1		$14,036,957	-5%	$14,775,744	15%	$16,992,106	$14,775,744	$15,284,054
Rehabilitated Areas	1	0%	1	0%	1		$4,580,802	-5%	$4,821,897	15%	$5,545,182	$4,821,897	$4,987,778
Roadway Demolition	1	0%	1	0%	1		$2,048,330	-5%	$2,156,137	15%	$2,479,558	$2,156,137	$2,230,312
Bridge Demolition (SF)	258,456	0%	258,456	0%	258,456	$35.00	$8,593,662	-5%	$9,045,960	15%	$10,402,854	$9,045,960	$9,357,156
											Roadway Subtotal	**$59,475,964**	$61,522,035
Structures													
WB I-215 over UPRR	18,212	-5%	19,170	5%	20,129	$241.25	$4,393,554	-5%	$4,624,794	10%	$5,087,273	$4,624,794	$4,783,232
Ramp ES over UPRR	9,892	-5%	10,413	5%	10,934	$269.60	$2,666,976	-5%	$2,807,343	10%	$3,088,077	$2,807,343	$2,903,518
Ramp ES over Ramp WS	4,817	-5%	5,070	5%	5,324	$322.15	$1,551,619	-5%	$1,633,283	10%	$1,796,611	$1,633,283	$1,689,236
Ramp MC over Ramp SE	13,452	-5%	14,160	5%	14,868	$219.43	$2,951,813	-5%	$3,107,172	10%	$3,417,889	$3,107,172	$3,213,618
Widen I-515 over Sunset	4,108	-5%	4,324	5%	4,540	$541.67	$2,225,060	-5%	$2,342,168	10%	$2,576,385	$2,342,168	$2,422,407
Widen I-515 over UPRR	2,850	-5%	3,000	5%	3,150	$374.57	$1,067,538	-5%	$1,123,724	10%	$1,236,096	$1,123,724	$1,162,221
Widen I-215 over Gibson	8,440	-5%	8,884	5%	9,328	$233.12	$1,967,518	-5%	$2,071,072	10%	$2,278,179	$2,071,072	$2,142,023
Ramp NE over I-11	30,987	-5%	32,618	5%	34,249	$178.88	$5,543,032	-5%	$5,834,770	10%	$6,418,247	$5,834,770	$6,034,659
Ramp MC over SB I-515	19,796	-5%	20,838	5%	21,880	$230.67	$4,566,351	-5%	$4,806,685	10%	$5,287,354	$4,806,685	$4,971,354
Ramp WN over UPRR	2,565	-5%	2,700	5%	2,835	$879.84	$2,256,783	-5%	$2,375,561	10%	$2,613,117	$2,375,561	$2,456,944
Ramp SE over UPRR	3,705	-5%	3,900	5%	4,095	$679.89	$2,518,999	-5%	$2,651,578	10%	$2,916,736	$2,651,578	$2,742,417
Eastern Crossover	9,548	-5%	10,050	5%	10,553	$285.28	$2,723,754	-5%	$2,867,109	10%	$3,153,820	$2,867,109	$2,965,331
Western Crossover	77,838	-5%	81,935	5%	86,032	$191.63	$14,916,254	-5%	$15,701,320	15%	$18,056,518	$15,701,320	$16,420,422
Ramp ES over Gibson	15,544	-5%	16,362	5%	17,180	$243.61	$3,786,596	-5%	$3,985,890	10%	$4,384,479	$3,985,890	$4,122,440
Widen I-515 over Warm Springs	20,449	-5%	21,525	5%	22,601	$186.82	$3,820,338	-5%	$4,021,408	10%	$4,423,549	$4,021,408	$4,159,175
Widen I-515 over Gibson	44,057	-5%	46,376	5%	48,695	$125.25	$5,518,170	-5%	$5,808,600	10%	$6,389,460	$5,808,600	$6,007,593
Redeck I-215 over UPRR	9,500	-5%	10,000	5%	10,500	$200.00	$1,900,000	-5%	$2,000,000	10%	$2,200,000	$2,000,000	$2,068,517
Retaining Walls													
Ramp MC over Ramp SE (Retaining Wall)	13,870	-10%	15,411	10%	16,952	$56.92	$833,334	-5%	$877,194	5%	$921,054	$877,194	$906,402
I-11 southbound (Retaining Wall)	63,450	-10%	70,500	10%	77,550	$56.92	$3,812,217	-5%	$4,012,860	5%	$4,213,503	$4,012,860	$4,146,477
I-515 (Retaining Wall)	32,400	-10%	36,000	10%	39,600	$56.92	$1,946,664	-5%	$2,049,120	5%	$2,151,576	$2,049,120	$2,117,350
I-215 (Retaining Wall)	68,850	-10%	76,500	10%	84,150	$56.92	$4,136,661	-5%	$4,354,380	5%	$4,572,099	$4,354,380	$4,499,369
Sound Walls													
I-11 (Sound Wall)	94,384	-15%	111,040	5%	116,592	$40.00	$4,219,520	-5%	$4,441,600	5%	$4,663,680	$4,441,600	$4,519,254
I-515 (Sound Wall)	167,960	-15%	197,600	5%	207,480	$40.00	$7,508,800	-5%	$7,904,000	5%	$8,299,200	$7,904,000	$8,042,188
											Structures Subtotal	**$91,401,631**	
Traffic													
Lake Mead Pkwy/Eastgate-Fiesta	1	0%	1	0%	1		$500,000	0%	$500,000	10%	$550,000	$500,000	$510,700
Lake Mead Pkwy/Van Wagenen	1	0%	1	0%	1		$500,000	0%	$500,000	10%	$550,000	$500,000	$510,700
											Traffic Subtotal	**$1,000,000**	
Utilities													
Known Utilities	1	0%	1	0%	1		$250,000	0%	$250,000	0%	$250,000	$250,000	$250,000
											Utility Subtotal	**$250,000**	
Drainage													
RCB Culvert Extensions (SF of new RCB Area)	5,032	0%	5,032	0%	5,032	$150.00	$732,156	-3%	$754,800	25%	$943,500	$754,800	$796,882
											Drainage Subtotal	**$754,800**	

Table A-1 –Baseline Cost Estimate

I-515/215 Henderson System Interchange - Improved Option 2A

Additional Items												
Additional Items	10.0%		10.0%		10.0%		$15,263,240		$15,263,240		$15,263,240	$15,263,240	$15,263,240
										Additional Item Subtotal	**$15,263,240**	
Risk Specific Items												
Identifier	**Description**		**Likelihood**	**Bournelli**		**Low**		**Most Likely**		**High**		
CN3	Additional embankment haul cost		Medium	1		$500,000		$1,500,000		$3,000,000		$1,842,189
CN4	Market conditions & material availability		Medium	1		$8,667,485		$17,334,970		$43,337,425		$23,298,484
CN5	Minor Change Orders		Low	0		$3,466,994		$6,067,240		$8,667,485		$0
D1	Add I-215 Stephanie to Pecos		Avoid	0		$40,000,000		$45,000,000		$50,000,000		$0
ENV3	Add I-515 sound wall south of I-215		Avoid	0		$1,000,000		$1,400,000		$2,000,000		$0
ENV9	NOA		High	1		$1,000,000		$2,500,000		$5,000,000		$3,072,603
RR2	Railroad Flagging		Very High	1		$250,000		$375,000		$500,000		$402,545
										Risk Specific Subtotal		$28,615,822
Sub-Total Present Day Construction Cost											**$168,145,635**	**$201,965,523**
Percentage Based Costs												
Landscaping and Aesthetics			3.0%				$4,817,373		$5,044,369		$5,044,369	$6,058,966
Traffic Control			10.0%				$16,057,911		$16,814,563		$16,814,563	$20,196,552
Roadside Safety			3.0%				$4,817,373		$5,044,369		$5,044,369	$6,058,966
Erosion Control			0.5%				$802,896		$840,728		$840,728	$1,009,828
										Subtotal	**$195,889,664**	**$235,289,834**
Mobilization			7.0%				$13,095,226		$13,712,276		$13,712,276	$16,470,288
Total Present Day Construction Cost											**$209,601,941**	**$251,760,123**
Soft Percentage Based Costs												
Preliminary Engineering & Final Design (PE)			6.0%				$12,010,193		$12,576,116		$12,576,116	$15,105,607
Right-of-Way Engineering			0.1%				$200,170		$209,602		$209,602	$251,760
Construction Engineering/Inspection (CE)			7.0%				$14,011,892		$14,672,136		$14,672,136	$17,623,209
Administration			1.0%				$2,001,699		$2,096,019		$2,096,019	$2,517,601
Legal			1.0%				$2,001,699		$2,096,019		$2,096,019	$2,517,601
Total Present Day Construction and Engineering Cost											**$241,251,834**	**$289,775,901**
Right-of-Way												
Right-of-Way Acquisition			1				$50,000	0%	$50,000	0%	$50,000	$50,000	$50,000
Stormwater/Environmental Mitigation												
Environmental Consideration			0.0%				$0		$0		$0	$0	$0
Overall Total Present Day Cost - Post Response											**$241,301,834**	**$289,825,901**

Table A-1 –Baseline Cost Estimate (Cont.)

APPENDIX B
Workshop Baseline Flow Chart

Figure B-1 –Baseline Flow Chart

APPENDIX C
Risk Register

Threat/Opportunity	Description	Status	Strategy	Option 2 - Pre-Response							Option 2 - Post Response							Notes
				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	
CONSTRUCTION																		
Other Large Events in the Area		Active	Accept	10%				0.5 MO	1 MO	2 MO	10%				0.5 MO	1 MO	2 MO	Minor Impacts - SNWA Horizon Lateral project (Northern Route). Construction could overlap.
Differing Site Conditions	Low risk as just expanding upon an existing interchange and foundations. Don't expect any surprises.	Inactive	Monitor															
Alternative requires 800k CUYDs for borrow.	Will need to identify source with R45 material. Risk is based potential additional haul costs.	Active	Mitigate	50%	$2 Mil	$3.5 Mil	$5 Mil				50%	$500k	$1.5 Mil	$3 Mil				6/8/21 - Quantity increased from 500k to 800k CUYD. Quantity of embankment in base estimate. Risk is potential additional hauling costs. Mitigation will include looking at phasing based on earthwork.
Market Conditions & Material Availability	Current inflation on construction materials and labor rates is high. Threat would be this does not level out or return to normal levels.	Active	Accept	50%	5%	10%	25%	3 MO	6 MO	9 MO	50%	5%	10%	25%	3 MO	6 MO	9 MO	6/8/21 - Includes material costs. Cost impacts in % of hard construction costs. Major materials (steel, lumber). Important to revisit this in a 1-2 years
Minor Change Orders	The risk accounts for 0.5%-2% of the total project costs to be used for minor change orders and unknown unknowns during construction.	Active	Mitigate	90%	2%	3.50%	5%	2 MO	3 MO	4 MO	25%	2%	3.50%	5%	2 MO	3 MO	4 MO	Mitigation - NDOT would need to minimize scope related changes to the project during construction.
CONTRACTING AND PROCUREMENT																		
Project Delivery Method	6/8/21 - Base assumption is D/B. Project could go D-B-B	Active	Accept	50%				TBD	TBD	TBD	50%				TBD	TBD	TBD	This is being reviewed as part of the on-going project. 6/8/21 - Base assumption is now DB
Wizard Estimation	Wizard utilizes 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	6/8/21 - Base assumption is D/B. R/W and Utility certs can be conditional for award.	Inactive	Monitor	25%					1MO									6/8/21 - Modified base contracting method to D/B. Need to revisit once final method is determined.
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															
Addition of I-215 Improvements from Stephanie to Pecos	These improvements are not in the STIP/RTP but could be added since County just completed widening west.	Active	Avoid	25%	$40 M	$45 M	$50 M											No change due to schedule since critical path lies within the core of the system interchange. Added 6/8/21. Strategy to avoid. If added, impacts would be back at pre-response levels.
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 of the I-11 project. Continue to monitor but inactive for now.	Inactive	Retired															Traffic model showed no impacts from new I-11 coming through the interchange. Coordination to continue but no additional improvements required. Retired 6/8/21.

Figure C-1 Risk Register

Threat/Opportunity	Description	Status	Strategy	Option 2 - Pre-Response							Option 2 - Post Response						Notes
				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	
Value Engineering for Design of Smaller Structures	Potential to reduce unit costs.	Inactive	Retired														This will be revisit to be addressed as alternatives are finalized and decided upon. VE process during the NEPA process have been incorporated. Savings included in 6/8/21 base estimate. Opportunity is retired.
Preliminary Engineering/Scoping takes longer than expected		Inactive															
Environmental and Hydraulics																	
Environmental Assessment (EA)	EA. Potential change it could go to CE	Inactive	Retired	25%				9 MO	10.5 MO	12 MO							6/8/21 - regardless of CE or EA schedule and cost as identified in the base will be the same.
Air Quality concerns	EPA to determine this summer. If a concern would extend NEPA 5 months	Active	Accept	50%				7 MO	9 MO	1 YR	50%				7 MO	9 MO	1 YR	Added 6/8/21 - Project team will need to make a strong argument on why air quality is not an issue. Team is working on developing documentation to support not having additional air quality work completed.
Potential addition of sound wall on I-515/I-11 South of the interchange	Local residential concern of a need for a sound wall. Potential political influence on inclusion into this project	Active	Avoid	10%	$1 Mil	$1.4 Mil	$2 Mil											Added 6/8/21 - Additional Construction Costs. Strategy is to avoid.
Delay in Alternative indecision	Potential indecision on a selected alternative	Inactive	Retired	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. 6/8/21 - Alternative has been identified and absorbed in current baseline schedule.
Nesting birds may delay construction	Risk of migratory birds nesting delaying start of bridge demolition or construction activities	Inactive	Monitor															6/8/21 changes in migratory bird act. Will need to review upcoming changes and see how those could impact the project.
Hazardous Materials discovered during excavation	Not a NEPA concern. Existing consolidation may be of concern. 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															Risk is very low and considered insignificant due to minimal excavation.
Regional Flood Control Facility	If channel is moved on west side 515, may require a CLOMR/LOMR by the City	Inactive	Retired															6/8/21 - No longer a risk based on identified alternative.
Naturally Occurring Asbestos and Poor Materials	Potential for NOA material within the project. Also includes unsuitable material possibly below surface.	Active	Accept	75%	$1 Mil	$2.5 Mil	$5 Mil				75%	$1 Mil	$2.5 Mil	$5 Mil				Revaluated during the design phase when additional geotech info is available.

Threat/Opportunity	Description	Status	Strategy	Option 2 - Pre-Response								Option 2 - Post Response								Notes
				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		
Management/Funding																				
NEPA Contract Approval	Current schedule anticipates going to Board meeting in March. May not be until April.	Inactive	Retired	50%				1 M	1 MO	3 MO										6/8/21 - Retired. Project now in NEPA
RAISE/INFRA/Rescissions/HR	Potential to obtain additional funds through RAISE/INFRA or rescissions.	Active	Accept	20%				-3 MO	-6 MO	-1 YR		20%				-3 MO	-6 MO	-1 YR		6/8/21 - Durations modified
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	10%				3 MO	6 MO	1 YR		10%				3 MO	6 MO	1 YR		6/8/21 - Durations modified
RIGHT-OF-WAY																				
Additional ROW needs.	Current design avoid right-of-way impacts as currently laid out.	Inactive	Retired	15%				9MO	18MO	24MO										6/8/21 - Team feels no risk for additional r/w. Retired
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		50%				0 MO	3 MO	6 MO		
Railroad Flagging	Risk is that base does not include railroad flagging costs.	Active	Accept	100%	$250k	$375k	$500k													Will just need to add to the base estimate.
STRUCTURES AND GEOTECH																				
Structure Costs	$240 for steel bridge + cost of retaining walls associated with the bridge. $175 for widening concrete bridge. New build $350 for concrete. Flyover bridges with high falsework were coded as steel bridges ($240). Centennial had large flyovers.	Inactive	Retired		150	170/sqft	190													6/8/21 - Retired. Addressed with updated base cost estimate and final feasibility study
Structures Cost	Double DDI cross-overs. Conservative on bridge quantity. (Base price $150/sqft). Maybe $25/sf high. (Alternative 3 only)	Inactive	Retired	100%	-70 SF	-535 SF	-530 SF													6/8/21 - Retired. Bridges are now traditional style.
UTILITIES																				
Utility Relocation/Coordination between Phases		Inactive																		
Utility Relocations	Potential SW Gas Relocation. 16" HP line	Inactive	Retired	100%	$400k	$500k	$600k	1 MO	2 MO	4 MO										6/8/21 - Retired. Alternative modified to avoid impact.

APPENDIX D
Additional Model Output

NDOT Risk Breakdown Structure Category*	I-15/Tropicana Interchange Risk Count			
	Active	Inactive	Retired	Total
Environmental & Hydraulics	3	3	3	9
Right-of-Way	0	0	1	1
Utilities	0	1	1	2
Design/PS&E	1	4	2	7
Structure & Geotech	0	0	2	2
Management/Funding	2	0	1	3
Contracting & Procurement	2	1	0	3
Construction	4	1	0	5
Total	**12**	**10**	**10**	**32**

Table D-1 – Henderson Interchange Risk Count Detail