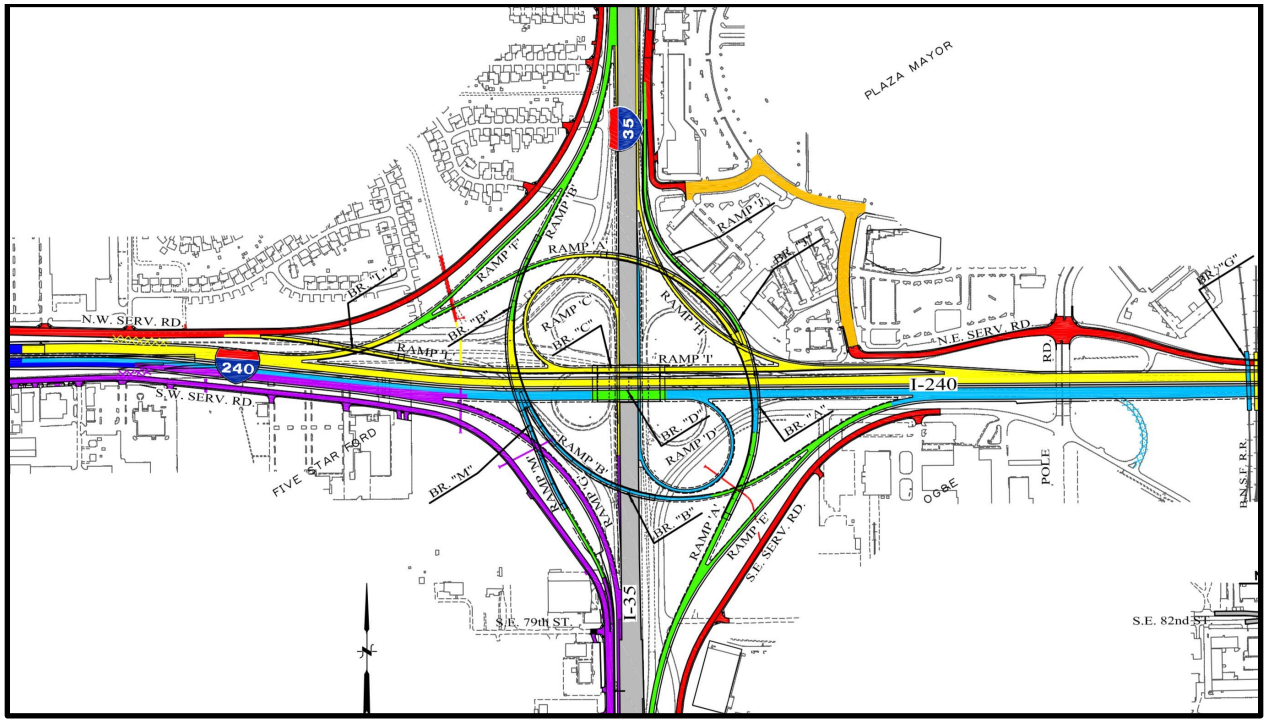
Crossroads of America: Replacing Bridges on I-35/I-240 in Oklahoma City

Benefit-Cost Analysis Technical Memorandum



Oklahoma Department of Transportation
FY2023-2026 U.S. DOT Bridge Investment Program
November 27, 2023

Executive Summary

The benefit-cost analysis evaluated the impacts of overhauling the I-35/I-240 interchange in Oklahoma City, Oklahoma as part of the ***Crossroads of America: Replacing Bridges on I-35/I-240 in Oklahoma City Project*** (or, "the Project"). The Project will replace the current outdated infrastructure with a safer, multilevel interchange featuring dedicated interstate ramps, frontage road turnaround lanes, and service roads for improved access to city streets. The Project will modernize the existing interchange and replace the structurally deficient I-240 bridge that runs over I-35. The Project will address safety issues by constructing new ramps and increasing merging distances, ensuring compatibility with current and anticipated traffic volumes. Furthermore, the transformation will alleviate congestion, improve operational challenges, and replace outdated elements with infrastructure that meets current standards.

In the analysis, the Project will include the environmental services, design, engineering and construction of the proposed improvements for roadway users on a phased schedule. Improving and expanding infrastructure for recreational, commuting and business users and freight vehicle will generate journey time savings and reductions in injuries and fatalities. Changes in roadway geometry and improvements throughout the interchange will alleviate peak hour conditions for autos and trucks, resulting in travel time savings for users, reductions in vehicle crashes, fuel cost savings and reduced vehicle emissions.

The construction activities of the Project are assumed to start in 2026 and be completed by the end of 2028 with full operations starting in 2029; environmental services, design, and engineering will be completed by 2023. The analysis period for the Project is 20 years of operations following project completion. The analysis was conducted in compliance with the U.S. DOT *Benefit-Cost Analysis Guidelines for Discretionary Grant Programs* published on January 2023. The methodology of the analysis conforms to U.S. DOT and other federal guidelines regarding benefit-cost analysis and was performed in line with industry standards and best practices.

The analysis was completed using a spreadsheet-based BCA tool specifically developed to evaluate the unique parameters and expected impacts of the Project. Consideration was given to use the BIP BCA Tool developed and strongly recommended by the U.S. DOT for use in applications to the Bridge Investment Program, yet the characteristics of the Project could not be fully evaluated using the BIP BCA Tool. Additionally, as the Project does not include traffic detours, expected bridge closures or load posting, using a customized BCA tool bests illustrates the impacts on users expected from the Project.

Executive Summary Matrix

Table ES-1 summarizes the key components of the analysis, describing the baseline status of roadway vehicle travel in the I-35/I-240 interchange and the expected impacts of the proposed project improvements.

Table ES-1. Executive Project Summary Matrix

Project Parameters	Description
Current Status / Baseline and Problem to be Addressed	Currently, recreational, commuting, business and freight vehicle-trips in the I-35/I-240 interchange currently experience congestion during the peak hour periods of the day, especially in areas with diverging and merging movements. The lack of service roads and interstate ramps connecting I-35 and I-240 results in traffic bottlenecks and collisions between vehicles, especially during diverging and merging movements. Traffic delays following vehicle collisions add to congested roadway conditions, increasing the emissions released by slow-moving and idling vehicles.
Change to Baseline Conditions / Alternatives	**No Build Alternative:** Under the current conditions, roadway traffic will continue to be exposed to the safety risks throughout the busy interchange, resulting in property damage, injuries and fatalities from incidents. Personal and freight vehicles will experience worsening congestion during peak hours, especially in diverging and merging areas.
	Build Alternative: The Project upgrades the existing interchange to a three-level, semi-directional partial cloverleaf interchange along I-35, from SE 66th to SE 82nd and along I-240 from Santa Fe Avenue to Eastern Avenue. The changes in roadway geometry, especially in diverging and merging areas, improves the flow of traffic throughout the interchange, reducing congestion-related delay during the peak period and reducing the risk of conflicts on the roadway.

Project Parameters	Description
Type of Impacts	**Reduction in Vehicle Collisions:** The Project provides safety benefits for personal and freight vehicles in the I-35/I-240 interchange by providing additional capacity to merging and diverging traffic, reducing conflicts between vehicles.
	Auto and Truck Travel Time Savings: The Project is expected to reduce the travel time for autos and trucks during the peak period by providing additional service roads and interstate ramps to facilitate traffic movements. Additionally, the reduction in collisions avoids traffic slowdowns that would occur while the roadway is cleared.
	Vehicle Fuel Cost Savings: The Project is expected to maintain free-flow travel speed in the corridor and reduce slowdowns related to vehicle collisions, allowing vehicles to reduce fuel consumption by operating at more fuel-efficient levels.
	Vehicle Emissions Reduction: The Project is expected to maintain free-flow travel speed in the corridor and reduce slowdowns related to vehicle collisions, allowing vehicles to reduce fuel consumption by operating at more fuel-efficient levels. The reduction in fuel consumption reduces the generation of vehicle emissions.
	Roadway and Bridge Rehabilitation Cost Savings: The construction of the Project will defer programmed rehabilitation of the roadway and the bridge, resulting in a cost savings for the maintaining agency.
	Residual Value: The proposed improvements included in the Project are expected to have a useful life of at least 75 years, representing a long-term investment in the corridor. The analysis monetizes the useful life of the capital investment remaining at the end of the 20-year analysis period.

Summary of Benefit-Cost Analysis Results

The benefit-cost analysis evaluates and monetizes the social benefits and costs of the Project over a 6-year design and construction period and a 20-year operations period. The construction period of the Project is expected to last from 2023 to the end of 2028; environmental services, design, and engineering will be complete by 2023 and construction will be complete by the end of 2028. The analysis period of the Project is, following the completion of construction, from 2029 to 2048. The analysis period evaluates the user and social benefits of the proposed project improvements in the project area. The benefits and costs evaluated in the analysis are calculated in 2021 constant dollars and their present value is calculated using a 7 percent discount rate, per U.S. DOT BCA guidance.[1]

Costs

The total capital cost of the Project is expected to be $152.7 million in year-of-expenditure dollars; the costs include $30.1 million for previously incurred expenses and $122.5 million for future construction costs. The capital costs for the Project represent the estimated costs for environmental, design, engineering and construction of the proposed project improvements based on the known concept parameters and schedule. When deflating from year-of-expenditure dollars assuming an annual escalation rate of 3.0 percent from 2023 to 2028, the capital costs are estimated to be $138.7 million in undiscounted 2021 dollars. At a 7 percent discount rate, the capital costs would be $89.3 million in 2021 dollars. The capital costs by year are summarized below in Table ES-2.

Table ES-2. Project Cost by Year (in millions of dollars)

Cost Category	2023	2024	2025	2026	2027	2028	Total
Year-of-expenditure dollars							
Environmental, Design and Engineering	$5.4	-	-	-	-	-	**$5.4**
Right-of-Way	$24.8	-	-	-	-	-	**$24.8**

[1] "Benefit-Cost Analysis Guidance for Discretionary Grant Programs", U.S. Department of Transportation, January 2023

Cost Category	2023	2024	2025	2026	2027	2028	Total
Construction	-	-	-	$40.8	$40.8	$40.8	**$122.5**
Total	**$30.2**	**-**	**-**	**$40.8**	**$40.8**	**$40.8**	**$152.7**
Adjusted 2021 constant dollars							
Environmental, Design and Engineering	$4.8	-	-	-	-	-	**$4.8**
Right-of-Way	$22.4	-	-	-	-	-	**$22.4**
Construction	-	-	-	$33.7	$32.7	$31.7	**$98.0**
Total	**$27.2**	**-**	**-**	**$33.7**	**$32.7**	**$31.7**	**$125.3**

The annual maintenance costs for all proposed project improvements are estimated to be $49,700 in 2021 dollars. The annual maintenance costs are based on the average roadway maintenance costs per lane-mile. Over the 20-year analysis period, the total maintenance costs for the project improvements are estimated to be $0.9 million in undiscounted 2021 dollars, or $0.3 million when discounted at 7 percent. The annal operations and maintenance costs are summarized below in Table ES-3.

Table ES-3. Annual Operations and Maintenance Costs (in undiscounted 2021 dollars)

	No Build Scenario	Build Scenario
Operations and Maintenance Costs	$4,500	$49,700

Benefits

The Project is expected to improve the roadway facilities for personal and freight traffic and alleviate the congestion conditions throughout the I-35/I-240 interchange. The construction of additional service roads, interstate ramps and flyovers to improve the connectivity between the I-35 and I-240 facilities will reduce journey time delay and injuries and fatalities from future crashes. Existing and future users of the interchange are expected to benefit from the improvements. Over the 20-year analysis period, the monetized impacts include the following:

Roadway Traffic Benefits

Auto and truck traffic traveling through the I-35/I-240 interchange are expected to experience improved traffic flow and reduced conflicts on the roadway. The analysis includes the modeled traffic conditions from the *Access Justification Report* prepared in 2015, which included peak hour traffic volumes and operational conditions for the freeway and ramp segments in the project area. The change in average travel delay during peak hours with and without the project improvements illustrates the benefits to roadway users.

Asset Useful Life and Residual Value

The analysis assumes a useful life of at least 75 years for the proposed improvements, signifying a significant capital investment in the corridor. The residual value measures the remaining value of the capital investment after the first 20 years of straight-line depreciation at the end of the analysis period.

Benefit-Cost Analysis Results

The total benefits generated from the project improvements within the analysis period are calculated to be $100.7 million in discounted 2021 dollars. The total capital costs, including design, preliminary engineering, and construction, are calculated to be $89.3 million in discounted 2021 dollars. The difference of the discounted benefits and costs equals a net present value of $11.4 million in discounted 2021 dollars, resulting in a benefit-cost ratio (BCR) of 1.13. Table ES-4 below summarizes the results of the base analysis for the Project by benefit category.

Table ES-4. BCA Summary Results (in 2021 dollars)

BCA Metric	Monetized Value	
	Undiscounted	**Discounted at 7%**
Total Benefits	**$340,239,000**	**$100,734,000**
Auto and Truck Travel Time Savings	*$29,933,000*	*$9,656,000*
Vehicle Fuel Cost Savings	*$579,000*	*$182,000*
Vehicle Emissions Reduction	*$96,000*	*$29,000*
Reduction in Vehicle Crashes	*$231,859,000*	*$76,484,000*
Residual Value	*$71,898,000*	*$11,571,000*
O&M/R&R Cost Savings	*$5,875,000*	*$2,812,000*
Total Capital Costs	**$125,322,000**	**$89,346,000**
Net Present Value	**$214,918,000**	**$11,388,000**
Benefit-Cost Ratio	**2.71**	**1.13**
Internal Rate of Return	**8%**	

Contents

Tables

1. Introduction

The benefit-cost analysis (BCA) evaluates Oklahoma Department of Transportation's (ODOT) proposed ***Crossroads of America: Replacing Bridges on I-35/I-240 in Oklahoma City Project*** (or, "the Project"), details the methodology and assumptions used to calculate benefits and costs, summarizes project benefits, and details project costs. The BCA is a requirement of the FY2023-2026 Bridge Investment Program (BIP) administered by the U.S. Department of Transportation (U.S. DOT).

1.1 BCA Framework

A BCA is an evaluation framework to assess the economic advantages (benefits) and disadvantages (costs) of an investment alternative. Benefits and costs are broadly defined and are quantified in monetary terms to the extent possible. The overall goal of a BCA is to assess whether the expected benefits of a project justify the costs from a national perspective. A BCA framework attempts to capture the net welfare change created by a project. It includes cost savings and increases in welfare (benefits), disbenefits where costs can be identified (e.g., project capital costs), and welfare reductions where some groups are expected to be made worse off as a result of the proposed project.

The BCA framework involves defining a Base Case or "No Build" Case, which is compared to the "Build" Case, where the grant request is awarded, and the project is built as proposed. The BCA assesses the incremental difference between the No Build Case and the Build Case, which represents the net change in welfare. BCAs are forward-looking exercises which seek to assess the incremental change in welfare over a project life cycle. The importance of future welfare changes is determined through discounting, which is meant to reflect both the opportunity cost of capital as well as the societal preference for the present.

The analysis was conducted in accordance with the benefit-cost methodology as recommended by the U.S. DOT in the *BCA Guidance for Discretionary Grant Programs* released in January 2023. This methodology includes the following analytical assumptions:

- Defining existing and future conditions under a No Build scenario and Build scenario;
- Estimating benefits and costs during project construction and operation, including 20 years of operations beyond the Project completion when benefits accrue;
- Using U.S. DOT recommended monetized values for travel time savings, vehicle operating cost savings, emissions and pedestrian benefits, while relying on best practices for monetization of other benefits;
- Presenting dollar values in real 2021 dollars. In instances where cost estimates and benefits valuations are expressed in historical or future dollar years, using an appropriate inflation rate to adjust the values;
- Discounting future benefits and costs with a real discount rate of 7 percent.

The analysis was completed using a spreadsheet-based BCA tool specifically developed to evaluate the unique parameters and expected impacts of the Project. Consideration was given to use the BIP BCA Tool developed and strongly recommended by the U.S. DOT for use in applications to the Bridge Investment Program, yet the characteristics of the Project could not be fully evaluated using the BIP BCA Tool. Additionally, as the Project does not include traffic detours, expected bridge closures or load posting, using a customized BCA tool bests illustrates the impacts on users expected from the Project.

1.2 Report Contents

The Report illustrates the methodology, assumptions and inputs used in the BCA and an evaluation of its results. Section 2 provides an explanation of the BCA methodology and a description of the project. Section 3 provides an explanation of the project costs. Section 4 provides an outline of the calculation of the benefit categories. Section 5 outlines the summary results of the BCA.

2. Project Overview

2.1 Description

With the increasing demand by users on personal, commuting and business trips and freight traffic in a critical interstate highway corridor, there is an urgent need to develop infrastructure to support reliable and safe traffic movement. ODOT will replace the current outdated infrastructure with a safer, multilevel interchange featuring dedicated interstate ramps, frontage road turnaround lanes, and service roads for improved access to city streets. The Project will modernize the existing interchange and replace the structurally deficient I-240 bridge that runs over I-35. The Project will address safety issues by constructing new ramps and increasing merging distances, ensuring compatibility with current and anticipated traffic volumes. Furthermore, the transformation will alleviate congestion, improve operational challenges, and replace outdated elements with infrastructure that meets current standards.

2.2 General Assumptions

The BCA requires a number of general assumptions that guide the overall analysis, presented below in Table 1.

Table 1: General Assumptions

Assumption	Value
Base Year Dollars	2023
Capital Cost Adjustment	Year-of-expenditure dollars adjusted to 2021 dollars
Real Discount Rate	7.0 percent (consistent with U.S. DOT guidance for discretionary grants and OMB Circular A-94)
Environmental/Design/Construction Start Date	2023
Environmental/Design/Construction End Date	2028
Project Opening	2029
End of Analysis Period	2048
Operations Period	20 years (post-construction)

2.3 Build and No-Build Scenario Comparison

The BCA assesses whether a proposed infrastructure investment is economically viable by comparing the quantified benefits to the expected costs of both the Build and No Build/Base Case. Benefits/ disbenefits are estimated through changes in user costs and impacts on the wider community with the project. Net project impacts are measured by comparing benefits to (a) capital costs and (b) ongoing operational expenditures for both the Build and No Build.

The No Build assumes the existing conditions in the I-35/I-240 interchange remain without any improvement. The current roadway geometry will continue to perform at constrained levels as traffic volumes increase over time, resulting in growing roadway congestion and crash risk. Merging and diverging traffic will continue to experience conflicts, resulting in worsening traffic performance. The rate of crashes experienced by vehicle traffic in the corridor will continue at historical levels.

The Build Case assumes the construction of the additional service roads, interstate ramps and flyovers in the I-35/I-240 interchange corridor will be completed. Enhancements in the roadway geometry improve the flow of traffic in the interchange, managing travel delay and reducing the risk of vehicle crashes. Slowdowns related to vehicle collisions will be reduced, ensuring traffic can travel through the area at free-flow speeds. Property damage, injuries and fatalities will be reduced due to a lower risk of vehicle collisions in the interchange area.

3. Project Costs

The expected costs associated with the Project include the capital expenditures for the design, engineering and construction of the Project and the change in annual operations and maintenance costs for maintaining the operationality of the proposed improvements.

3.1 Project Capital Costs

The Project includes the previously expended and future costs for design, engineering and construction services required to develop all the project elements. The capital expenditures are expressed in year-of-expenditure dollars with 2023 as the base year for the cost estimate of material, labor and services for a total value of $152.7 million. The costs are converted to constant 2021 dollars for a total value of $125.3 million. Using a discount rate of 7 percent, the capital costs are valued at $89.3 million in 2021 dollars. Table 2 shows the breakdown of capital expenditures by cost category and year in year-of-expenditure dollars and constant 2021 dollars.

Table 2: Capital Expenditures by Category and Year (in millions of dollars)

Cost Category	2023	2024	2025	2026	2027	2028	Total
Year-of-expenditure dollars							
Environmental, Design and Engineering	$5.4	-	-	-	-	-	**$5.4**
Right-of-Way	$24.8	-	-	-	-	-	**$24.8**
Construction	-	-	-	$40.8	$40.8	$40.8	**$122.5**
Total	**$30.2**	**-**	**-**	**$40.8**	**$40.8**	**$40.8**	**$152.7**
Adjusted 2021 constant dollars							
Environmental, Design and Engineering	$4.8	-	-	-	-	-	**$4.8**
Right-of-Way	$22.4	-	-	-	-	-	**$22.4**
Construction	-	-	-	$33.7	$32.7	$31.7	**$98.0**
Total	**$27.2**	**-**	**-**	**$33.7**	**$32.7**	**$31.7**	**$125.3**

3.2 Project Operations and Maintenance Costs

The annual maintenance costs for all proposed project improvements are estimated to be $49,700 in 2021 dollars. The annual maintenance costs are based on the average roadway maintenance costs per lane-mile. Over the 20-year analysis period, the total maintenance costs for the project improvements are estimated to be $0.9 million in undiscounted 2021 dollars, or $0.3 million when discounted at 7 percent. The annal operations and maintenance costs are summarized below in Table 3.

Table 3: Annual Operations and Maintenance Costs (in undiscounted 2021 dollars)

	No Build Scenario	Build Scenario
Operations and Maintenance Costs	$4,500	$49,700

4. Project Impacts

The Project is expected to result in the following impacts to existing and new pedestrian users and roadway traffic users in the Kagy Boulevard corridor:

- Auto and Truck Travel Time Savings;
- Reduction in Roadway Crashes;
- Vehicle Fuel Costs Savings;
- Vehicle Emissions Reduction; and,
- Residual Value

The quantifying of these benefits is based on a projection of future existing and new users related to their proximity to improved pedestrian and bicyclist facilities and the standardized economic value of those improvements, based on the *U.S. DOT BCA Guidance for Discretionary Grant Programs* published in January 2023.

4.1 Traffic Analysis

The analysis evaluates the traffic conditions and traffic volumes in the project area presented in the *Access Justification Report: I-35/I-240 Interchange* prepared for the Oklahoma Department of Transportation in July 2015. The traffic report includes the existing and projected vehicle AM and PM peak hour volumes and average travel speed for the freeway and ramp segments of the I-35/I-240 interchange for the years 2013 and 2040. The peak period is defined as the sum of three AM peak hours and three PM peak hours, while the off-peak period captures the remaining 18 hours of the day; an annualization factor of 310 days per year is used for the traffic analysis. The peak period traffic volumes and average travel speed are calculated for several segments of the interchange; each segment presents traffic volumes and operational conditions in both directions. The off-peak period traffic conditions are assumed to operate at free-flow speeds under the No Build and Build scenarios.

Table 4: Projected Daily Traffic Vehicle-Trips on Freeway Segments in Project Area by Freeway Direction

Year	I-35 Northbound	I-35 Southbound	I-240 Eastbound	I-240 Westbound
2013	60,800	64,800	45,900	28,900
2029 (Project Opening)	65,300	70,000	54,200	40,500
2040	68,500	73,900	60,700	51,100

The peak period and off-peak period traffic volumes are calculated for the freeway segments of the I-35/I-240 interchange. The average travel speed for the No Build and Build scenarios are calculated using a Level of Service (LOS) analysis based on the roadway capacity of the existing and proposed roadway segments and the projected traffic volumes per hour during the peak and off-peak period. Based on the LOS analysis, the proposed improvements are expected to mitigate the majority of traffic-induced congestion in the project area, compared to the No Build condition.

Table 5: The 2040 Level of Service (LOS) in the Eight Primary Movements, Existing & Proposed Design

The Eight Primary Movements			Existing Conditions	Proposed Design
Diverging		**Merging**	**LOS AM/PM Peak Hour Diverging---(Merging)**	
I-35 Northbound	**to**	**I-240 Eastbound**	E/E---(E/E)	D/C---(B/A)
		I-240 Westbound	F/F---(F/F)	D/C---(C/D)
I-35 Northbound	**to**	**I-240 Eastbound**	B/C---(E/F)	C/C---(B/A)
		I-240 Westbound	E/F---(E/F)	C/C---(C/D)
I-240 Eastbound	**to**	**I-35 Northbound**	E/F---(F/F)	C/C---(E/E)
		I-35 Southbound	F/F---(F/F)	A/B---(v/c < 1)
I-240 Westbound	**to**	**I-35 Northbound**	C/D---(E/E)	B/B---(D/D)
		I-35 Southbound	F/F---(B/C)	B/B---(D/D)

The vehicle-miles traveled (VMT) are calculated from the projected traffic volumes and the length of each freeway segment by direction.

Table 6: Projected Daily Vehicle-Miles Traveled in Project Area by Freeway Direction

Year	I-35 Northbound	I-35 Southbound	I-240 Eastbound	I-240 Westbound
2013	121,600	129,600	91,800	57,800
2029 (Project Opening)	130,600	140,000	108,400	81,000
2040	137,000	147,800	121,400	102,200

The detailed calculations of volumes, travel delay, vehicle-hours traveled, and vehicle-miles traveled for vehicle traffic are provided in the "Traffic Data Analysis" tab of the BCA spreadsheet file.

4.1.1 Collision-Related Traffic Delay

In addition to evaluating the change in the normal traffic operations, the analysis evaluates the impact of traffic slowdowns related to vehicle collisions in the freeway and ramp segments. A vehicle collision results in a temporary closure of at least one lane of traffic through the interchange, resulting in lower-than-average travel speeds for vehicles traveling through the area. Based on the expected reduction in collisions due to the proposed improvements, a portion of the traffic slowdowns related to collisions will be avoided, allowing vehicles to travel at free-flow speeds.

Table 7: Projected Annual Vehicle-Miles Traveled Affected by Collision-Related Traffic Delay

Year	No Build	Build	Net Difference
2023	4,294,000	3,220,500	1,073,500
2029 (Project Opening)	4,527,100	3,395,300	1,131,800
2040	4,987,800	3,740,900	1,247,000

Based on the vehicle-miles traveled affected by traffic slowdowns from vehicle collisions, the additional travel delay can be calculated using the projected travel speed during traffic slowdowns and in free-flow conditions. The difference in the travel delay results from the avoided traffic slowdowns from the reduction in vehicle collisions.

Table 8: Projected Annual Vehicle-Hours of Delay from Collision-Related Traffic Slowdown

Year	Average Travel Speed (MPH)		Travel Delay (VHTs)		
	Free-Flow	Post-Collision	No Build	Build	Net Difference
2023	66	26	162,200	121,700	40,500
2029 (Project Opening)	66	26	172,400	129,300	43,100
2040	65	26	192,800	144,600	48,200

4.2 Auto and Truck Traffic Benefits

With the proposed construction of the additional service roads, interstate ramps and flyovers, auto and truck traffic in the project area is expected to experience improved operational conditions during the peak hour period, as compared to the No Build conditions. The *Access Justification Report: I-35/I-240 Interchange* prepared in 2015 included modeled traffic conditions during the peak hour period with and without the proposed project improvements in the forecast year 2040, using 2013 as the base year. The calculation of these impacts is based on the change of traffic conditions during the peak hour period, which the analysis defines as six hours per weekday; users traveling in off-peak hours are calculated to make up 52 percent of daily traffic volume. Vehicles in the off-peak period are assumed to experience free-flow conditions at intersections. For the freeway segments, the average peak and off-peak travel speed in the No Build and Build scenarios are calculated using a Level of Service (LOS) analysis. The calculated travel delay includes the impacts of the traffic slowdowns from collisions.

Table 9: Projected Avoided Travel Delay in Project Area

	2029	2048
Travel Time Savings (PHT, Auto)	66,200	80,300
Travel Time Savings (PHT, Trucks)	3,400	4,200

Over the 20-year analysis period, the total value of auto and truck travel time savings is estimated to be $29.9 million in undiscounted 2021 dollars. Assuming a base year of 2021 and real discount rate of 7 percent, the net present value of vehicle travel time savings is calculated to be $9.7 million in discounted 2021 dollars. Table 10 summarizes the monetized value of vehicle travel time savings.

Table 10: Value of Auto and Truck Travel Time Savings (in 2021 dollars)

	Monetized Value (undiscounted)	Monetized Value (discounted @ 7%)
Total Benefits	**$29,933,000**	**$9,656,000**

4.2.1 Reduction in Roadway Crashes

The analysis calculates the reduction in crashes involving roadway vehicles related to the proposed project improvements in the I-35/I-240 interchange by applying the appropriate crash modification factor to the historical average crashes in the project area. The historical data on vehicle crashes is organized by location, crash severity and mode of travel from 2012 to 2021. Based on the characteristics of the improvements throughout the project area, a percentage of crashes involving roadway vehicles in the interchange were expected to be avoided in the future. The diversity of roadway improvements included in the project scope provides the opportunity for several options of crash modification factors to be applied to the historical crash data. As the improvements are adding additional functional capacity for merging and diverging traffic traveling between I-35 and I-240, the crash modification factor chosen to assess the change in crash risk is CMF 8335 (“Install an Additional Lane”). Based on this crash modification factor, the risk of future vehicle collisions and related damages would be reduced by 25 percent.

Table 11: Crash History for Vehicles and Pedestrians in Project Area (2012 to 2021)

Crash Severity	Number of Crashes	Annual Average	Annual Avoided Crashes
No Injury (Property Damage Only)	7,061	706.1	176.5
Possible Injury	1,642	164.2	41.1
Non-Incapacitating Injury	530	53.0	13.3
Incapacitating Injury	148	14.8	3.7
Fatality	12	1.2	0.3
Total	**1,879**	**187.9**	**234.8**

Over the 20-year analysis period, the total value of avoided crashes involving roadway vehicles is estimated to be $231.9 million in undiscounted 2021 dollars. Assuming a base year of 2021 and real discount rate of 7 percent, the net present value of avoided crashes involving roadway vehicles is calculated to be $76.5 million in discounted 2021 dollars. Table 12 summarizes the monetized value of avoided property damage, injuries and fatalities.

Table 12: Value of Avoided Property Damage, Injuries and Fatalities (in 2021 dollars)

	Monetized Value (undiscounted)	Monetized Value (discounted @ 7%)
Total Benefits	$231,859,000	$76,484,000

4.2.2 Vehicle Fuel Cost Savings

The analysis calculates the reduction in vehicle fuel costs related to the difference in travel speeds under the No Build and Build scenarios. The proposed roadway improvements are expected to maintain higher travel speeds, allowing vehicles to consume fuel more efficiently. The economic value of fuel cost savings is calculated by applying the projected cost of gasoline and diesel, as provided in the *2023 Annual Energy Outlook* published by the Energy Information Administration, to the reduction in fuel consumed.

Over the 20-year analysis period, the total value of vehicle fuel cost savings is estimated to be $0.6 million in undiscounted 2021 dollars. Assuming a base year of 2021 and real discount rate of 7 percent, the net present value of vehicle fuel cost savings is calculated to be $0.2 million in discounted 2021 dollars. Table 13 summarizes the monetized value of vehicle fuel cost savings.

Table 13: Value of Vehicle Fuel Cost Savings (in 2021 dollars)

	Monetized Value (undiscounted)	Monetized Value (discounted @ 7%)
Total Benefits	$579,000	$182,000

4.2.3 Vehicle Emissions Reduction

The analysis calculates the reduction in vehicle emissions related to the proposed project improvements by applying emissions factors by vehicle travel speed and the standardized economic values per metric ton of emissions gas, as defined in the U.S. DOT BCA guidance documents. The Project is not expected to change the number of vehicle-miles traveled in the project area, but the change in travel speed in the No Build and Build scenarios allows vehicles to consume fuel more efficiently. The emissions factors by vehicle travel speed vary by emissions type and the standardized social costs of vehicle emissions vary by year. Based on the Project's improvement of connectivity between the I-35 and I-240 highways and local arterial roadways, future users would likely be able to take more direct routes to complete their trips, further avoiding vehicle emissions.

Table 14: Avoided Vehicle Emissions in Project Area (in metric tons)

	Avoided Emissions over 20-Year Analysis Period
Emissions – NO_X	(0.535)
Emissions - $PM_{2.5}$	(0.025)
Emissions – SO_X	(0.014)
Emissions - CO_2	1,712

Note: Values in parentheses "()" indicate an increase in vehicle emissions.

Over the 20-year analysis period, the total value of avoided vehicle emissions is estimated to be $96,000 in undiscounted 2021 dollars. Assuming a base year of 2021 and real discount rate of 7 percent, the net present value of avoided vehicle emissions is calculated to be $29,000 in discounted 2021 dollars. Table 15 summarizes the monetized value of avoided vehicle emissions.

Table 15: Avoided Vehicle Emissions Benefits (in 2021 dollars)

	Monetized Value (undiscounted)	Monetized Value (discounted @ 7%)
Total Benefits	$96,000	$29,000

4.3 Roadway and Building Rehabilitation Cost Savings

The Project signifies a significant investment in the state of good repair of the I-35/I-240 interchange. By making the investment now, the Project will result in the deferral of programmed major rehabilitation of the roadway and bridge structures. Deferring these costs into the future are considered a cost savings and included in the project benefits.

Table 16: Major Rehabilitation Costs Over the Analysis Period (in undiscounted 2021 dollars)

	No Build	Build	Net Difference
Rehabilitation Costs	$13,557,000	$6,778,000	$6,779,000

Over the 20-year analysis period, the total cost savings for major rehabilitation work are estimated to be $6.8 million in undiscounted 2021 dollars, or $3.1 million when discounted at 7 percent. The cost savings for major rehabilitation work are summarized below in Table 17.

Table 17: Major Rehabilitation Cost Savings (in 2021 dollars)

	Monetized Value (undiscounted)	Monetized Value (discounted @ 7%)
Total Benefits	$6,779,000	$3,110,000

4.4 Residual Value

The residual value is calculated by determining the percentage of useful life remaining beyond the analysis period and multiplying that percentage by the construction cost for that component. With a 20-year analysis period and an estimated 75-year design life for the Project, the residual value is 73% of the initial cost using the straight-line depreciation method. The remaining capital value is viewed as a cost offset or "negative cost" and is applied to the last year of analysis period as a benefit. The residual value of $71.9 million is discounted back to $11.6 million in discounted 2021 dollars.

Table 18: Residual Value (in 2021 dollars)

	Monetized Value (undiscounted)	Monetized Value (discounted at 7%)
Residual Value	$71,898,000	$11,571,000

5. Benefit-Cost Analysis Results

5.1 Evaluation Measures

The BCA converts potential gains (benefits) and losses (costs) with the Project into monetary units and compares them. The following common benefit-cost evaluation measures are included in this BCA:

- **Net Present Value (NPV):** NPV compares the net benefits (benefits minus costs) after being discounted to present values using the real discount rate assumption. The NPV provides a perspective on the overall dollar magnitude of cash flows over time in today's dollar terms.
- **Benefit Cost Ratio (BCR):** The evaluation also estimates the benefit-cost ratio; the present value of incremental benefits is divided by the present value of incremental costs to yield the benefit-cost ratio. The BCR expresses the relation of discounted benefits to discounted costs as a measure of the extent to which a project's benefits either exceed or fall short of the costs.
- **Internal Rate of Return (IRR):** The IRR is the discount rate which makes the NPV from the Project equal to zero. In other words, it is the discount rate at which the Project breaks even. Generally, the greater the IRR, the more desirable the Project.

5.2 BCA Results

The summary of the benefit-cost analysis is outlined in the table below. The results are in constant 2021 dollars discounted at 7 percent, as prescribed by the U.S. DOT BCA Guidance documents. All benefits and costs are calculated in constant 2021 dollars over an evaluation period extending 20 years after the end of construction. The total benefits from the project improvements within the analysis period are calculated to be $100.7 million in discounted 2021 dollars. The total capital costs, including design, engineering, and construction, are calculated to be $89.3 million in discounted 2021 dollars. The difference of the discounted benefits and costs equal a net present

value of $11.4 million in discounted 2021 dollars, resulting in a benefit-cost ratio (BCR) of 1.13. The internal rate of return for the Project is 8 percent.

Table 19: Summary of Benefit-Cost Analysis (in 2021 dollars)

BCA Metric	Monetized Value	
	Undiscounted	Discounted at 7%
Total Benefits	**$340,239,000**	**$100,734,000**
Auto and Truck Travel Time Savings	*$29,933,000*	*$9,656,000*
Vehicle Fuel Cost Savings	*$579,000*	*$182,000*
Vehicle Emissions Reduction	*$96,000*	*$29,000*
Reduction in Vehicle Crashes	*$231,859,000*	*$76,484,000*
Residual Value	*$71,898,000*	*$11,571,000*
O&M/R&R Cost Savings	*$5,875,000*	*$2,812,000*
Total Capital Costs	**$125,322,000**	**$89,346,000**
Net Present Value	**$214,918,000**	**$11,388,000**
Benefit-Cost Ratio	**2.71**	**1.13**
Internal Rate of Return	**8%**	