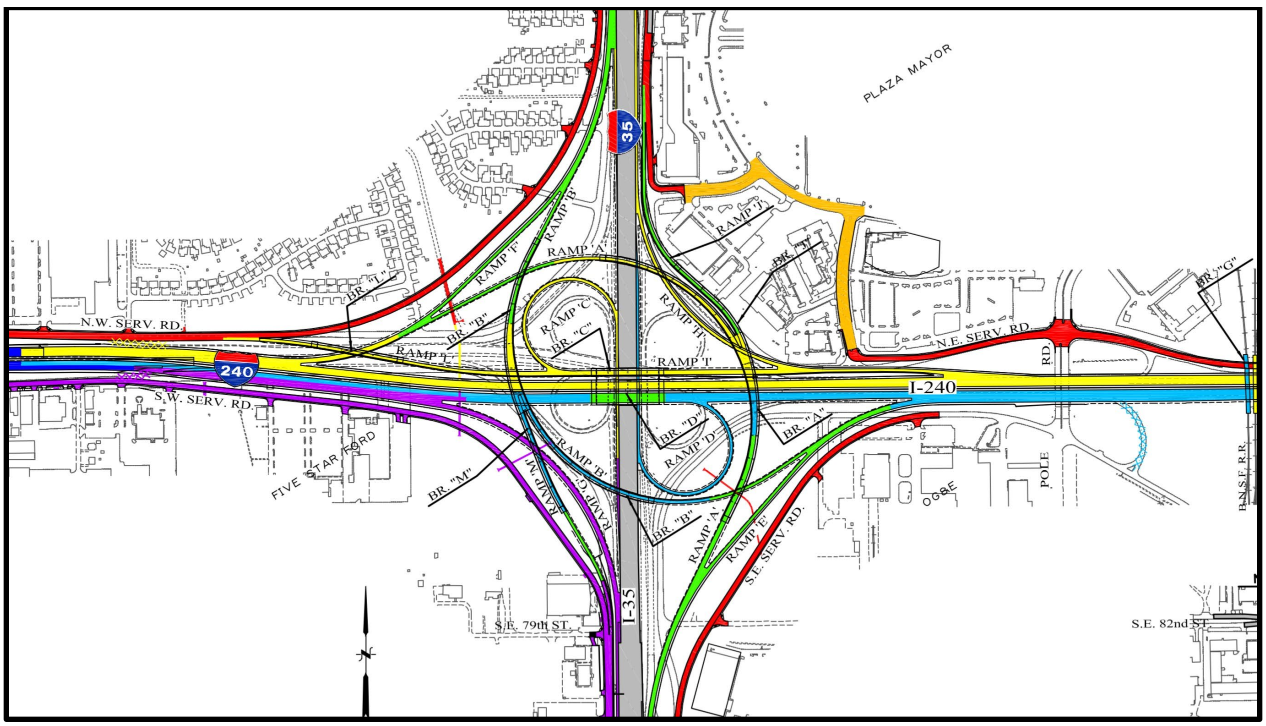
Crossroads of America: Replacing Bridges on I-35/I-240 in Oklahoma City

Benefit-Cost Analysis Technical Memorandum



Oklahoma Department of Transportation
FY2023-2026 FHWA Bridge Improvement Program (BIP) Large Bridge Project
August 1, 2024

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 The Project will replace the current outdated infrastructure with a safer, multilevel interchange featuring dedicated interstate ramps, frontage road turnaround lanes, and service roads for improved access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 Furthermore, the transformation will alleviate congestion, improve operational challenges, and replace outdated elements with infrastructure that meets current standards.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 vehicles 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 *Benefit-Cost Analysis Guidelines for Discretionary Grant Programs* published by the U.S. Department of Transportation (USDOT) in December 2023. The methodology of the analysis conforms to USDOT and other federal guidelines regarding benefit-cost analysis and was performed in line with industry standards and best practices.

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 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, improve the flow of traffic throughout the interchange, reducing congestion-related delays during the peak period and reducing the risk of conflicts on the roadway.
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 eliminating weaving sections, extending decelerations and acceleration lanes, and providing additional capacity to merging and diverging traffic, reducing conflicts between vehicles.

Project Parameters	Description
	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 movement. 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 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 2022 constant dollars and their present value is calculated using a 3.1 percent discount rate, per USDOT BCA guidance; the value of CO_2 emissions is evaluated using a 2.0 percent discount rate.[1]

Costs

The total capital cost of the Project is expected to be $153 million in year-of-expenditure dollars; the costs include $30 million for previously incurred expenses and $123 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 $135 million in undiscounted 2022 dollars. At a 3.1 percent discount rate, the capital costs would be $120 million in 2022 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**
Construction	-	-	-	$52.5	$52.5	$17.5	**$122.5**
Total	**$30.2**	**-**	**-**	**$52.5**	**$52.5**	**$17.5**	**$152.7**

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

Cost Category	2023	2024	2025	2026	2027	2028	Total
Adjusted 2022 constant dollars							
Environmental, Design and Engineering	$5.2	-	-	-	-	-	**$5.2**
Right-of-Way	$24.0	-	-	-	-	-	**$24.0**
Construction	-	-	-	$46.4	$45.0	$14.5	**$105.9**
Total	**$29.2**	**-**	**-**	**$46.4**	**$45.0**	**$14.5**	**$135.1**

The annual maintenance costs for the current infrastructure and proposed project improvements are estimated to be $126,000 in undiscounted 2022 dollars, as compared to $77,000 in the No Build scenario. The annual maintenance costs are based on the average roadway maintenance costs per lane-mile for roadway facilities in Oklahoma. Over the 20-year analysis period, the net maintenance costs for the project improvements are estimated to be $1.0 million in undiscounted 2022 dollars, or $0.6 million when discounted at 3.1 percent. The annual operations and maintenance costs are summarized below in Table ES-3.

Table ES-3. Annual Operations and Maintenance Costs (in undiscounted 2022 dollars)

	No Build Scenario	Build Scenario
Operations and Maintenance Costs	$77,000	$126,000

The major rehabilitation and repair costs for all proposed project improvements are estimated to be $7.3 million in 2022 dollars under the Build scenario, as compared to $14.5 million under the No Build scenario. The major rehabilitation and repair cost savings are based on the planned rehabilitation costs for the facility with and without the Project. Over the 20-year analysis period, the net major rehabilitation and repair cost savings for the project improvements are estimated to be $7.3 million in undiscounted 2022 dollars, or $5.3 million when discounted at 3.1 percent. The major rehabilitation and repair cost savings are summarized below in Table ES-4.

Table ES-4. Total Rehabilitation and Repair Cost Savings (in undiscounted 2022 dollars)

	No Build Scenario	Build Scenario
Rehabilitation and Repair Cost Savings	$14,511,000	$7,256,000

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 delays 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. Improvements in the dimensions of the deceleration and acceleration lanes, the removal of the weaving sections and the construction of flyover ramps are expected to reduce the frequent roadway conflicts on the facility.

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 $177 million in discounted 2022 dollars. The total capital costs, including design, preliminary engineering, and construction, are calculated to be $120 million in discounted 2022 dollars. The difference between the discounted benefits and costs equals a net present value of $57 million in discounted 2022 dollars, resulting in a benefit-cost ratio (BCR) of 1.48. Table ES-4 below summarizes the results of the base analysis for the Project by benefit category.

Table ES-4. BCA Summary Results (in 2022 dollars)

BCA Metric	Monetized Value	
	Undiscounted	Discounted
Total Benefits	**$308,271,000**	**$177,379,000**
Auto and Truck Travel Time Savings	*$18,242,000*	*$11,080,000*
Vehicle Fuel Cost Savings	*$380,000*	*$229,000*
Vehicle Emissions Reduction	*$288,000*	*$172,000*
Reduction in Vehicle Crashes	*$205,446,000*	*$126,078,000*
Residual Value	*$77,627,000*	*$35,098,000*
O&M/R&R Cost Savings	*$6,288,000*	*$4,723,000*
Total Capital Costs	**$135,054,000**	**$120,049,000**
Net Present Value	**$173,217,000**	**$57,330,000**
Benefit-Cost Ratio	**2.28**	**1.48**
Internal Rate of Return	**6.2%**	

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 Improvement Program (BIP) Large Bridge Project administered by the Federal Highway Administration (FHWA).

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 because 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 value of future welfare changes is determined through discounting, which reflects both the opportunity cost of capital and the societal preference for the present.

The analysis was conducted in accordance with the benefit-cost methodology as recommended by the U.S. Department of Transportation (USDOT) in the *Benefit-Cost Analysis Guidance for Discretionary Grant Programs* published in December 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 USDOT 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 2022 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 3.1 percent; the value of CO_2 emissions is discounted at a rate of 2 percent.

1.2 Report Contents

The Report illustrates the methodology, assumptions and inputs used in the BCA and an evaluation of its results. Section 2 explains the BCA methodology and describes the project. Section 3 explains 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	2022 (USDOT BCA Guidance)
Capital Cost Adjustment	Year-of-expenditure dollars adjusted to 2022 dollars
Real Discount Rate	3.1 percent, excluding CO_2 emissions; 2.0 percent for CO_2 emissions (consistent with USDOT BCA Guidance 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 total capital cost of the Project is expected to be $153 million in year-of-expenditure dollars; the costs include $30 million for previously incurred expenses and $123 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 $135 million in undiscounted 2022 dollars. At a 3.1 percent discount rate, the capital costs would be $120 million in 2022 dollars. Table 2 shows the breakdown of capital expenditures by cost category and year in year-of-expenditure dollars and constant 2022 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	-	-	-	$52.5	$52.5	$17.5	**$122.5**
Total	**$30.2**	**-**	**-**	**$52.5**	**$52.5**	**$17.5**	**$152.7**
Adjusted 2022 constant dollars							
Environmental, Design and Engineering	$5.2	-	-	-	-	-	**$5.2**
Right-of-Way	$24.0	-	-	-	-	-	**$24.0**
Construction	-	-	-	$46.4	$45.0	$14.5	**$105.9**
Total	**$29.2**	**-**	**-**	**$46.4**	**$45.0**	**$14.5**	**$135.1**

3.2 Project Operations and Maintenance Costs

The annual maintenance costs for the current infrastructure and proposed project improvements are estimated to be $126,000 in undiscounted 2022 dollars, as compared to $77,000 in the No Build scenario. The annual maintenance costs are based on the average roadway maintenance costs per lane-mile for roadway facilities in Oklahoma. Over the 20-year analysis period, the net maintenance costs for the project improvements are estimated to be $1.0 million in undiscounted 2022 dollars, or $0.6 million when discounted at 3.1 percent. The annual operations and maintenance costs are summarized below in Table 3.

Table 3: Annual Operations and Maintenance Costs (in undiscounted 2022 dollars)

	No Build Scenario	Build Scenario
Operations and Maintenance Costs	$77,000	$126,000

3.3 Project Major Rehabilitation and Repair Costs

The major rehabilitation and repair costs for all proposed project improvements are estimated to be $7.3 million in 2022 dollars under the Build scenario, as compared to $14.5 million under the No Build scenario. The major rehabilitation and repair cost savings are based on the planned rehabilitation costs for the facility with and without the Project. Over the 20-year analysis period, the net major rehabilitation and repair cost savings for the project improvements are estimated to be $7.3 million in undiscounted 2022 dollars, or $5.3 million when discounted at 3.1 percent. The major rehabilitation and repair cost savings are summarized below in Table 4.

Table 4: Total Rehabilitation and Repair Cost Savings (in undiscounted 2022 dollars)

	No Build Scenario	Build Scenario
Rehabilitation and Repair Cost Savings	$14,511,000	$7,256,000

4. Project Impacts

The Project is expected to result in the following impacts to existing and new roadway traffic users in the I-35 and I-240 highway corridors:

- 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 the proposed improvements in the project area and the standardized economic value of those improvements, based on the *Benefit-Cost Analysis Guidance for Discretionary Grant Programs* published by the USDOT in December 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 (link provided in the footnotes).[2] 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. As an interchange for two significant interstate highways, the facility is expected to function at peak level continuously throughout the day. To account for the performance of the facility using the modeled traffic data, a limited peak period is defined to avoid overcounting the impacts of the proposed improvements. Using the modeled traffic data on the AM and PM peak hours in the year 2040, the peak hour traffic is calculated to be 8.4 percent of daily traffic. The peak period is defined as the sum of three AM peak hours and three PM peak hours, representing 51 percent of daily vehicle-trips as traveling under peak hour conditions. The off-peak period captures the remaining 18 hours of the day, representing 49 percent of daily vehicle-trips. During the off-peak hours, traffic is expected to perform at free-flow conditions under the No Build and Build scenarios. 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.

Table 5: 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

[2] Oklahoma Department of Transportation, *Access Justification Report: I-35/I-240 Interchange,* July 2015, https://oklahoma.gov/content/dam/ok/en/odot/federal-grants/bridge-investment-program/2023_2024/crossroads-of-america-replacing-bridges-on-i-35-i-240-in-oklahoma-city/prelim-engineering/Access%20Justification%20Report.pdf

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 6: 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 7: 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 8: Projected Annual Vehicle-Miles Traveled Affected by Collision-Related Traffic Delay

Year	No Build	Build	Net Difference
2023	4,070,000	-	-
2029 (Project Opening)	4,290,500	3,631,200	659,300
2048 (Last Year of Analysis Period)	5,072,300	4,292,900	779,500

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 9: 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	154,200	-	-
2029	66	26	163,900	138,800	25,200
2048	65	25	199,100	168,500	30,600

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 49 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 10: Projected Avoided Travel Delay in Project Area

	2029	2048
Travel Time Savings (PHT, Auto)	38,700	47,000
Travel Time Savings (PHT, Trucks)	2,000	2,400

Over the 20-year analysis period, the total value of auto and truck travel time savings is estimated to be $18 million in undiscounted 2022 dollars. Assuming a base year of 2022 and real discount rate of 3.1 percent, the net present value of vehicle travel time savings is calculated to be $11 million in discounted 2022 dollars. Table 11 summarizes the monetized value of vehicle travel time savings.

Table 11: Value of Auto and Truck Travel Time Savings (in 2022 dollars)

	Monetized Value (undiscounted)	Monetized Value (discounted)
Total Benefits	**$18,242,000**	**$11,080,000**

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 factors 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. An overview of the crash modification factors considered in the analysis are shown below in Table 12.

Table 12: Review of Crash Modification Factors

Crash Modification Factor	CMF ID	Crash Modification Factor (CMF)	Crash Reduction (%)
Provide Straight Ramp Instead of Cloverleaf Ramp	478	0.55	45%
Extend Acceleration Lane by 100 Feet	474	0.89	11%
Extend Deceleration Lane by 100 Feet	475	0.93	7%

As the improvements are adding additional functional capacity for merging and diverging traffic traveling between I-35 and I-240, the crash modification factor is applied to crashes in the project area expected to be reduced in the future. Evaluating the effect of the proposed improvements on crash rates in a complex interchange is difficult, given the discrete nature of the changes to the roadway geometry and the addition of ramps to better facilitate traffic movements. For crashes expected to occur in the ramp sections of the interchange, the curve tightness of the cloverleaf ramps presents the clearest danger, resulting in rear-end crashes between vehicles due to sudden braking. For crashes expected to occur in the weaving sections of the mainline segments, the merging and diverging movement of the vehicles results in sideways and rear-end collisions. Based on consultations with safety engineers and the traffic operations analysts, a percentage of crashes were identified is likely to be related to these phenomena in the interchange area; not all crashes are expected to be affected by the proposed improvements. The detailed calculations of vehicle crashes in the project area are provided in the “Safety Inputs” tab of the BCA spreadsheet file; a summary of the detailed crash data is provided in the “Crash Data” tab.

Table 13: Assumptions about Evaluating Crashes Affected by Project Improvements

Percentage of Total Crashes Caused by Sideswipe	19%
Percentage of Total Crashes Caused by Rear-End	69%
Percentage of Total Crashes Caused by Other Cause	12%
Percentage of Total Crashes Involved in Merging and Diverging Movements	34%
Percentage of Total Crashes Involved in Ramp Movements	21%
Percentage of Total Crashes Affected by Project Improvements	**54%**
Percentage Reduction in Total Crashes, Weighted Average	**15%**

Based on these assumptions, the percentage of total crashes from the data likely to be affected by the proposed project improvements can be estimated. Due to the distribution of the crashes throughout the project area and the dynamics of traffic movements in the interchange area, it is difficult to determine specifically which crashes would be avoided in the future. Instead, the analysis applies the calculated average reduction in crashes to the profile of all crashes in the project area, which is assumed to represent the average outcome of a roadway collision. The summary of the crashes in the project area by collision severity and the expected avoided future crashes are shown below in Table 14.

Table 14: Summary of Crashes in Project Area (2012 to 2021)

Crash Severity	Number of Crashes	Annual Average	Annual Avoided Crashes
No Injury (Property Damage Only)	7,058	705.8	108.5
Possible Injury	1,642	164.2	25.2
Non-Incapacitating Injury	530	53.0	8.1
Incapacitating Injury	148	14.8	2.3
Fatality	12	1.2	0.2
Total	**9,390**	**939**	**144.3**

Over the 20-year analysis period, the total value of avoided crashes involving roadway vehicles is estimated to be $205 million in undiscounted 2022 dollars. Assuming a base year of 2022 and real discount rate of 3.1 percent, the net present value of avoided crashes involving roadway vehicles is calculated to be $126 million in discounted 2022 dollars. Table 15 summarizes the monetized value of avoided property damage, injuries and fatalities.

Table 15: Value of Avoided Property Damage, Injuries and Fatalities (in 2022 dollars)

	Monetized Value (undiscounted)	Monetized Value (discounted)
Total Benefits	$205,446,000	$126,078,000

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. The analysis calculates, over the 20-year analysis period, the consumption of 90,200 gallons of gasoline and 25,300 gallons of diesel will be avoided.

Over the 20-year analysis period, the total value of vehicle fuel cost savings is estimated to be $0.4 million in undiscounted 2022 dollars. Assuming a base year of 2022 and real discount rate of 3.1 percent, the net present value of vehicle fuel cost savings is calculated to be $0.2 million in discounted 2022 dollars. Table 16 summarizes the monetized value of vehicle fuel cost savings.

Table 16: Value of Vehicle Fuel Cost Savings (in 2022 dollars)

	Monetized Value (undiscounted)	Monetized Value (discounted)
Total Benefits	$380,000	$229,000

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 USDOT 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 17: Avoided Vehicle Emissions in Project Area (in metric tons)

	Avoided Emissions over 20-Year Analysis Period
Emissions – NO_X	(0.298)
Emissions - $PM_{2.5}$	(0.014)
Emissions – SO_X	(0.008)
Emissions - CO_2	1,051

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 $0.3 million in undiscounted 2022 dollars. Assuming a base year of 2022 and real discount rate of 3.1 percent, the net present value of avoided vehicle emissions is calculated to be $0.2 million in discounted 2022 dollars; the value of CO_2 emissions are discounted at a rate of 2.0 percent. Table 18 summarizes the monetized value of avoided vehicle emissions.

Table 18: Avoided Vehicle Emissions Benefits (in 2022 dollars)

	Monetized Value (undiscounted)	Monetized Value (discounted)
Total Benefits	$288,000	$172,000

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 19: Major Rehabilitation Costs Over the Analysis Period (in undiscounted 2022 dollars)

	No Build	Build	Net Difference
Rehabilitation Costs	$14,511,000	$7,256,000	$7,256,000

Over the 20-year analysis period, the total cost savings for major rehabilitation work are estimated to be $7.3 million in undiscounted 2022 dollars, or $5.3 million when discounted at 3.1 percent. The cost savings for major rehabilitation work are summarized below in Table 20.

Table 20: Major Rehabilitation Cost Savings (in 2022 dollars)

	Monetized Value (undiscounted)	Monetized Value (discounted)
Total Benefits	$7,256,000	$5,316,000

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 percent 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. At the end of the 20-year analysis period, the residual is estimated to be $78 million in undiscounted 2022 dollars, or $35 million when discounted at 3.1 percent. The residual value is summarized below in Table 21.

Table 21: Residual Value (in 2022 dollars)

	Monetized Value (undiscounted)	Monetized Value (discounted)
Residual Value	$77,627,000	$35,098,000

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. The greater the IRR, the more desirable the Project.

5.2 Summary of BCA Results

The summary of the benefit-cost analysis is outlined in the table below. The results are in constant 2022 dollars discounted at 3.1 percent, as prescribed by the USDOT BCA Guidance documents; the value of CO_2 emissions is discounted at a rate of 2.0 percent. All benefits and costs are calculated in constant 2022 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 $177 million in discounted 2022 dollars. The total capital costs, including design, engineering, and construction, are calculated to be $120 million in discounted 2022 dollars. The difference of the discounted benefits and costs equal a net present value of $57 million in discounted 2022 dollars, resulting in a benefit-cost ratio (BCR) of 1.48. The internal rate of return for the Project is 6.2 percent.

Table 22: Summary of Benefit-Cost Analysis (in 2022 dollars)

BCA Metric	Monetized Value	
	Undiscounted	Discounted
Total Benefits	**$308,271,000**	**$177,379,000**
Auto and Truck Travel Time Savings	*$18,242,000*	*$11,080,000*
Vehicle Fuel Cost Savings	*$380,000*	*$229,000*
Vehicle Emissions Reduction	*$288,000*	*$172,000*
Reduction in Vehicle Crashes	*$205,446,000*	*$126,078,000*
Residual Value	*$77,627,000*	*$35,098,000*
O&M/R&R Cost Savings	*$6,288,000*	*$4,723,000*
Total Capital Costs	**$135,054,000**	**$120,049,000**
Net Present Value	**$173,217,000**	**$57,330,000**
Benefit-Cost Ratio	**2.28**	**1.48**
Internal Rate of Return	**6.2%**	

6. Sensitivity Analyses

6.1 Revision of Residual Value Assumption

The proposed improvements in the roadway infrastructure included in the scope of the Project represents a long-term capital investment in the interstate roadway system. The proposed improvements are expected to generate user and social benefits throughout their useful life of at least 75 years. While the analysis period evaluating the benefits and costs of the Project is limited to 20 years, the remaining value of the capital investment is represented in the residual value benefit. For the Project, the annual user and social benefits are expected to continue to exceed their costs beyond the 20-year analysis period. To demonstrate the Project would be a cost-effective investment within the 20-year analysis period, a sensitivity analysis was completed to calculate the benefits and costs of the Project without the residual value benefit. The summary of the BCA results without the calculation of the residual value is shown below in Table 23

Table 23: Summary of Benefit-Cost Analysis Without Residual Value Benefit (in 2022 dollars)

BCA Metric	Monetized Value	
	Undiscounted	Discounted
Total Benefits	**$230,644,000**	**$142,282,000**
Auto and Truck Travel Time Savings	*$18,242,000*	*$11,080,000*

BCA Metric	Monetized Value	
	Undiscounted	Discounted
Vehicle Fuel Cost Savings	*$380,000*	*$229,000*
Vehicle Emissions Reduction	*$288,000*	*$172,000*
Reduction in Vehicle Crashes	*$205,446,000*	*$126,078,000*
Residual Value	-	-
O&M/R&R Cost Savings	*$6,288,000*	*$4,723,000*
Total Capital Costs	**$135,054,000**	**$120,049,000**
Net Present Value	**$95,590,000**	**$22,233,000**
Benefit-Cost Ratio	**1.71**	**1.19**
Internal Rate of Return	**4.7%**	

6.2 Revision of Traffic Safety Analysis

Given the technical difficulties in measuring the change in vehicles crashes related to the proposed improvements in the interchange, a sensitivity analysis was developed to evaluate the variation in the BCA results after using alternative crash modification factors and crash data for the Project. The approach of using crash modification factors to evaluate future vehicle crashes, as described in the *Benefit-Cost Analysis Guidelines for Discretionary Grant Programs* published by the USDOT, is limited to evaluating how proposed changes in the roadway geometry and/or safety infrastructure would affect the historical crashes. The approach cannot predict the crash risk of new infrastructure, given the lack of information on historical crashes. Additionally, the complexity of the roadway geometry of the interchange and the specific characteristics of the proposed improvements make it difficult to identify a suitable crash modification factor of sufficient quality to be applied to the historical crash data, resulting in the safety benefits of the Project to be undercounted.

The crash modification factors for evaluating acceleration and deceleration lanes are based on changes in their relative length. For context, the current length of the existing ramps expected to be modified by the proposed improvements averages 500 feet while the proposed design for the ramps adjusts their length to 1,000 feet and longer. To illustrate the range of options applicable to the Project, a number of crash modification factors related to the extension of acceleration and deceleration lanes were considered in the sensitivity analysis; the factors apply to all types of crashes and collision severities. The description of the crash modification factors under consideration are detailed below in Table 23.

Table 24: Review of Alternative Crash Modification Factors

Crash Modification Factor	CMF ID	Rating (out of 5)	CMF Value	Crash Reduction (%)
Extend acceleration lane by approx. 98 ft (30 m)	474	3	0.89	11%
Extend deceleration lane by approx. 100 ft	475	3	0.93	7%
Change length of deceleration lane from 401-500 ft. to 601-700 ft.	4681	2	0.59	41%
Change length of deceleration lane from 501-600 ft. to 601-700 ft.	4682	2	0.98	2%
Change length of deceleration lane from less than 100 ft. to 601-700 ft.	4677	2	0.02	98%
Provide an auxiliary lane between an entrance ramp and exit ramp	3898	3	0.8	20%

Crash Modification Factor	CMF ID	Rating (out of 5)	CMF Value	Crash Reduction (%)
Extend acceleration lane by approx. 98 ft (30 m)	474	3	0.89	11%
Extend deceleration lane by approx. 100 ft	475	3	0.93	7%
Provide an auxiliary lane for weaving between an entrance ramp and exit ramp	7440	1	0.79	21%

While none of the crash modification factors specifically address the expected change in vehicle crashes for extending the acceleration and deceleration lanes in the interchange from 500 feet to 1,000 feet, we could assume a reduction of 20 percent to 40 percent. The crash modification factors identified in the table apply to all crash types and crash severities, according to the CMF Clearinghouse, but we will apply them only to side-swipe crashes and rear-end crashes commonly associated with merging and diverging movements. To adjust for traffic conflicts on the mainline segments of the interchange, the analysis assumes only 50 percent of rear-end crashes in the project area are related to merging and diverging movements. Refer to the tab labeled "Safety Inputs_Revised" for the calculations of the crash data and crash modification factors used in the sensitivity analysis.

The summary of crashes from merging and diverging movements occurring in the interchange between mileposts 0.59 and 1.20 of I-35 and mileposts 4.44 and 4.72 of I-240 (representing a total length of 0.89 linear miles of roadway) are shown below in Table 24. Refer to the tab labeled "Crash Data_Revised" for the detailed summary of the crash data used in the sensitivity analysis.

Table 25: Merging and Diverging Movement Crashes by Collision Severity (2012 to 2021)

Collision Severity	Total Count	Annual Average
No Injury	6,297	630
Possible Injury	1,451	145
Non-Capacitating	370	37
Suspected Serious Injury	107	11
Fatality	0	0
Total	**8,225**	**823**

The sensitivity analysis adapts the safety analysis to consider alternative crash modification factors and revise the population of vehicle crashes expected to be affected by the proposed improvements, but all other factors remain unchanged relative to the original analysis. However, the change in the expected number of vehicle crashes does affect the results of other areas of the analysis, including the roadway congestion related to vehicle crashes. The results of the sensitivity analysis are shown below in Table 25.

Table 26: Summary of Benefit-Cost Analysis with Revised Traffic Safety Analysis (in 2022 dollars)

BCA Metric	Monetized Value (discounted)	
	Original Analysis	Sensitivity Analysis
Total Benefits	**$177,379,000**	**$144,577,000**
Auto and Truck Travel Time Savings	*$11,080,000*	*$11,705,000*
Vehicle Fuel Cost Savings	*$229,000*	*$242,000*
Vehicle Emissions Reduction	*$172,000*	*$181,000*
Reduction in Vehicle Crashes	*$126,078,000*	*$92,628,000*
Residual Value	*$35,098,000*	*$35,098,000*
O&M/R&R Cost Savings	*$4,723,000*	*$4,723,000*
Total Capital Costs	**$120,049,000**	**$120,049,000**

BCA Metric	Monetized Value (discounted)	
	Original Analysis	Sensitivity Analysis
Net Present Value	**$57,330,000**	**$24,528,000**
Benefit-Cost Ratio	**1.48**	**1.20**
Internal Rate of Return	**6.2%**	**4.5%**

In the BCA model, the only required changes to replicate the sensitivity analysis include the following:

- linking the cells in rows 21 to 27 in the "Intermediate Calcs" tab to cells H66 to H71 in the "Safety Inputs_Revised" tab; and,
- linking the cells H723 to H728 in the "Traffic Data Analysis" tab to cells H57 to H62 in the "Safety Inputs_Revised" tab.