Benefit Cost Analysis Narrative

Multimodal Improvements to Safety Connect Tulsa at the US-75 and W. 81st Street Interchange

Tulsa, Oklahoma

February 28, 2023

OKLAHOMA Transportation

Table of Contents

Benefit-Cost Analysis

Executive Summary

The Benefit-Cost Analysis (BCA) of this grant application compares the costs and benefits of the proposed investment project. To the extent possible, expected benefits were monetized. A qualitative discussion is presented for benefits that are more difficult to quantify.

The Oklahoma Department of Transportation (ODOT) and City of Tulsa (COT) propose to reconstruct the existing US-75/W. 81st Street interchange as a Diverging Diamond Interchange (DDI), provide additional capacity on W. 81 Street, and provide new pedestrian and bicycle facilities across US-75. This innovative design will improve safety and traffic flow and provide a connection for non-vehicular traffic where none exists today. Specific improvements planned as part of the project include:

- Replace the northbound and southbound bridges on US-75 over W. 81st Street as 70'-wide steel bridges to accommodate future widening of US-75,
- Reconstruct the existing standard diamond interchange to a diverging diamond interchange (DDI), including accommodation for bicycles and pedestrians across US-75,
- Reconstruct the portions of US-75 and interchange ramps necessary to accommodate the new bridges and interchange with new concrete pavement,
- Widen W. 81st Street from S. Tacoma Ave. across US-75 through the eastern ramp intersection to a 5-lane section including two 12'-wide lanes in each direction, a 12' center turn lane, and 12' multipurpose trail on both sides, and
- Construct subsurface storm drain on W. 81st Street to convey stormwater.

Table 1 below summarizes the changes expected from the project, and the associated quantified benefits. The period of analysis used in the estimation of benefits and costs is 23 years, including one year of project development, two years of construction, and 20 years of operations[1]. Total project development and construction costs (undiscounted) are estimated at $21.8 million in 2021 dollars. For this BCA, cost estimates were de-escalated or escalated to 2021 dollars depending upon the year the cost estimate was completed using the GDP deflator, per USDOT BCA Guideline requirements.

All relevant data and calculations used to derive the benefits and costs of the project are shown in the BCA model that accompanies this grant application. Based on the analysis presented in the rest of this document, the Project is expected to generate $21.7 million in discounted benefits, $15.8 million in discounted capital costs, and generate of $1.2 million in discounted maintenance savings, using a 7 percent real discount rate[2]. Therefore, the Project is expected to generate a Net Present Value of $7.0 million and a Benefit/Cost Ratio of 1.48 as shown below in **Table 2** and **Figure 1**.

[1] Sensitivity analysis also considered an evaluation period with 30 years of Project operations. The results of this analysis (for Project NPV and BC ratio) are reported in the BCA Sensitivity Analysis section while the BCA spreadsheet model submitted with this application contains full results.

[2] All benefits, costs and savings are discounted at 7%, except for CO2 which was discounted at 3% per USDOT BCA Guidelines

Table 1: Summary of Benefits

Baseline Status and Problems to be Addressed	Changes to Baseline	Types of Impacts & Benefits	Population Affected by Impacts	Benefit Value (2021 $ millions, 7% discount)
The US-75 corridor is included in the top 5% of freight bottlenecks in the Tulsa area and is listed as a critical freight corridor in ODOT's State Freight Plan. A specific challenge associated with the interchange is to adequately accommodate existing future and travel demand. The current interchange movements are operating at a Level of Service D and AM and PM peak hours are showing a total network delay of 47 and 44 vehicle hours of delay, respectively. Additionally, there are no multimodal accommodations across US-75.	The Oklahoma Department of Transportation (ODOT) and City of Tulsa (COT) propose to reconstruct the existing US-75/W. 81st Street interchange as a diverging diamond interchange (DDI), provide additional capacity on W. 81 Street, and provide new pedestrian and bicycle facilities across US-75. This innovative design will improve safety and traffic flow and provide a connection for non-vehicular traffic where none exists today.	***Impact*** - New diverging diamond interchange ***Benefit*** - Improved vehicle safety	Vehicle Owners and Truck Operators	$ 1.51
		Impact - Reduced vehicular delays at interchange and reduced distances for pedestrian routes ***Benefit*** - Reduction in travel times	Vehicle Owners, Truck Operators, and Pedestrians	$ 17.62
		Impact - Shorter delays at interchange ***Benefit*** - Reduced vehicle operating costs (fuel reduction)	Vehicle Owners and Truck Operators	$ 0.70
		Impact - Reduced time spent idling during intersection delays ***Benefit*** - Emissions reduction	Vehicle Owners, Truck Operators, and Residents of adjacent communities	$ 0.07
		Impact - New sidewalks providing reduced walking distances and walk/cycling times ***Benefit*** – Enhanced pedestrians and cyclist amenities and mobility	Residents of adjacent communities, Pedestrians & Cyclists	$ 0.82
		Impact - New bridges at proposed interchange ***Benefit*** - Reduced bridge hits and reduced maintenance costs over the life of the project.	Vehicle Owners, Truck Operators, and ODOT	$ 0.01
		Impact - New bridges at proposed interchange ***Benefit*** - Extended residual life of bridges at proposed interchange	ODOT	$ 0.93
Total				**$ 21.7**

Table 2: Summary of BCA Outcomes, Millions of Dollars in 2021

Project Evaluation Metric	Undiscounted	Present Value at 3% Discount Rate	Present Value at 7% Discount Rate
Total Benefits	$64.3	$39.2	$21.7
Total O&M (Cost) / Savings	$3.5	$2.2	$1.2
Total Capital (Cost) / Savings	$(21.5)	$(18.8)	$(15.8)
Net Present Value (NPV)	$46.2	$22.5	$7.0
Benefit / Cost Ratio	3.56	2.35	**1.48**
Internal Rate of Return	11.1%		

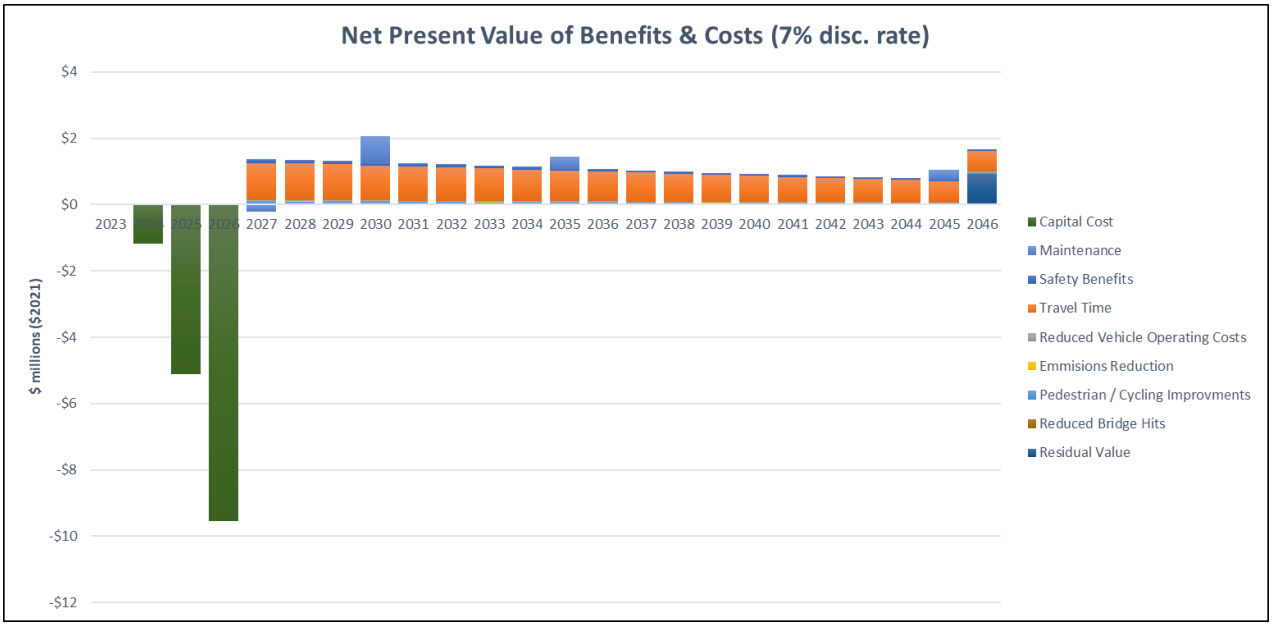

Figure 1: Net Present Value of Benefits and Costs (7% Discount Rate)

In addition to the monetized benefits, the project is expected to generate benefits that are more difficult to quantify. A brief description of those benefits is provided below:

- **Improved Mobility and Community Connectivity:** The Project will improve traffic flow at the US-75/W. 81st Street Interchange through the construction of a diverging diamond interchange (DDI). The Project will provide a multimodal connection across US-75 and improve access to amenities on both sides of US-75. The Project will increase access to bus transit, facilitating access to job centers such as Tulsa Hills, as well as vital services and amenities along the routes. Routes in this corridor also provide access to downtown Tulsa, which offers jobs and government services. After the connection under US-75 is completed, many pedestrians will experience shorter walking distances and walking times to these destinations. Improved mobility of area residents can then be expected to reduce barriers to opportunities more generally, including barriers to education and employment.

- **Quality of Life:** The area lacks a connected sidewalk network connecting its residents to a variety of destinations. By providing a safer and shorter pedestrian connection, the Project will increase access to affordable transportation choices for non-motorized travelers. The installation of a multi-use path across US-75 will encourage a modal shift to transit and active transportation and could reduce vehicle miles traveled.

- **Economic Competitiveness**: The US-75/W. 81st Street Interchange project will promote long-term economic growth in the US-75 corridor. Designated for commercial development in the City of Tulsa's comprehensive plan (Planitulsa), it is anticipated that the land adjacent to US-75 on both sides of the highway will continue to develop with commercial property and the Project will enhance mobility for future development.

Introduction and Methodology

This document provides detailed technical information on the benefit-cost analysis (BCA) conducted in support of the grant application for the Project. The BCA includes the monetized benefits and costs measured using USDOT guidance, as well as the quantitative and qualitative merits of the project. A BCA provides estimates of the benefits that are expected to accrue from a project over a specified period and compares them to the anticipated costs of the project. Costs include both the resources required to develop the project and the costs of maintaining the new or improved asset over time. Estimated benefits are based on the projected impacts of the project on both users and non-users of the facility, valued in monetary terms.

While a BCA is just one of many tools that can be used in making decisions about infrastructure investments, it provides a useful benchmark from which to evaluate and compare potential transportation investments. The specific methodology adopted for this application is based on the BCA guidance developed by USDOT[3] and is consistent with the RAISE program guidelines. In particular, the methodology involves:

- Establishing existing and future conditions under the build and no-build scenarios,
- Assessing benefits with respect to project requirements listed in RAISE Notice of Funding Opportunity (NOFO) document,
- Measuring benefits in dollar terms, whenever possible, and expressing benefits and costs in a common unit of measurement,
- Using USDOT guidance for the valuation of travel time savings, and safety benefits, while relying on industry best practices for the valuation of other effects,
- Discounting future benefits and costs with the real discount rate recommended by USDOT (7 percent, except for carbon dioxide, which is discounted at 3 percent, per USDOT BCA Guidelines), and
- Conducting a sensitivity analysis to assess the impacts of changes in key input assumptions.

[3] USDOT, Benefit-Cost Analysis Guidance for Discretionary Grant Programs, January 2023 Revised

Project Overview

The Project entails reconstruction of the US-75/W. 81st Street interchange and associated improvements on W. 81st Street in the city of Tulsa, Oklahoma (**Figure 2**). US-75 is on the National Highway System (NHS) and National Highway Freight Network (NHFN) and is among the highest volume truck freight routes in the state. US-75 is included in the top 5% of freight bottlenecks in the Tulsa area and is listed as a critical freight corridor in ODOT's State Freight Plan, 2023-2030.

The Project proposes to reconstruct the existing US-75/W. 81st Street interchange as a diverging diamond interchange (DDI), provide additional capacity on W. 81 Street, and provide new pedestrian and bicycle facilities across US-75 (**Figure 3**). This innovative design will improve safety and traffic flow and provide a connection for non-vehicular traffic where none exists today. Specific improvements planned as part of the project include:

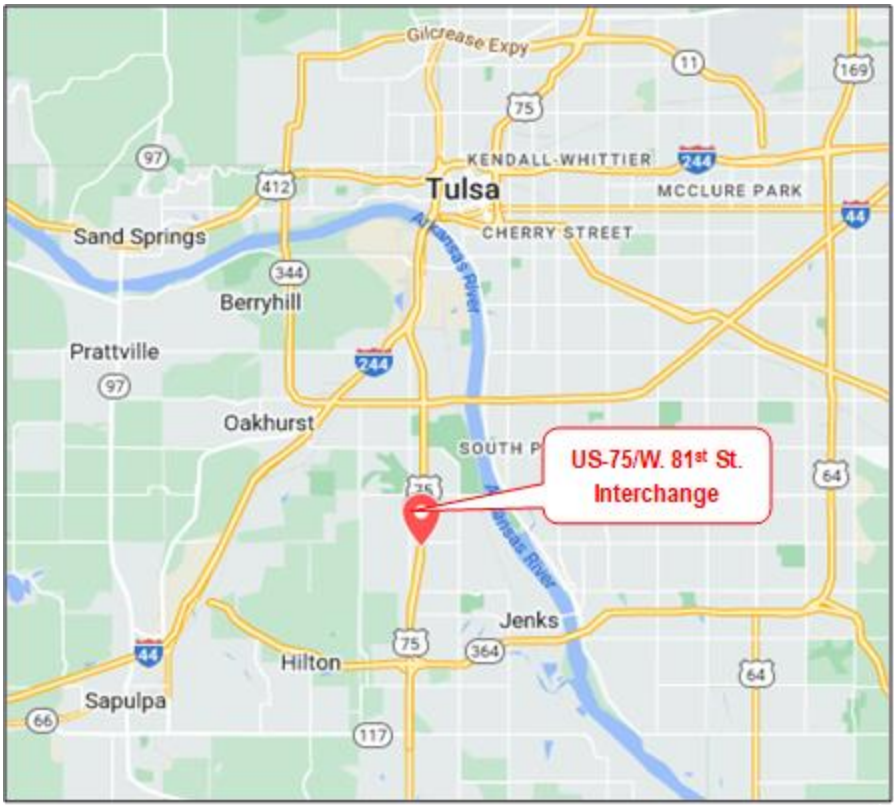

Figure 2: US-75/W. 81st Street Interchange Location Map

- Replace the northbound and southbound bridges on US-75 over W. 81st Street as 70'-wide steel bridges to accommodate future widening of US-75,
- Reconstruct the existing standard diamond interchange to a diverging diamond interchange (DDI), including accommodation for bicycles and pedestrians across US-75,
- Reconstruct the portions of US-75 and interchange ramps necessary to accommodate the new bridges and interchange with new concrete pavement,
- Widen W. 81st Street from S. Tacoma Ave. across US-75 through the eastern ramp intersection to a 5-lane section including two 12'-wide lanes in each direction, a 12' center turn lane, and 12' multipurpose trail on both sides (**Figure 4**), and
- Construct subsurface storm drain on W. 81st Street to convey stormwater.

Figure 3: Proposed Diverging Diamond Interchange

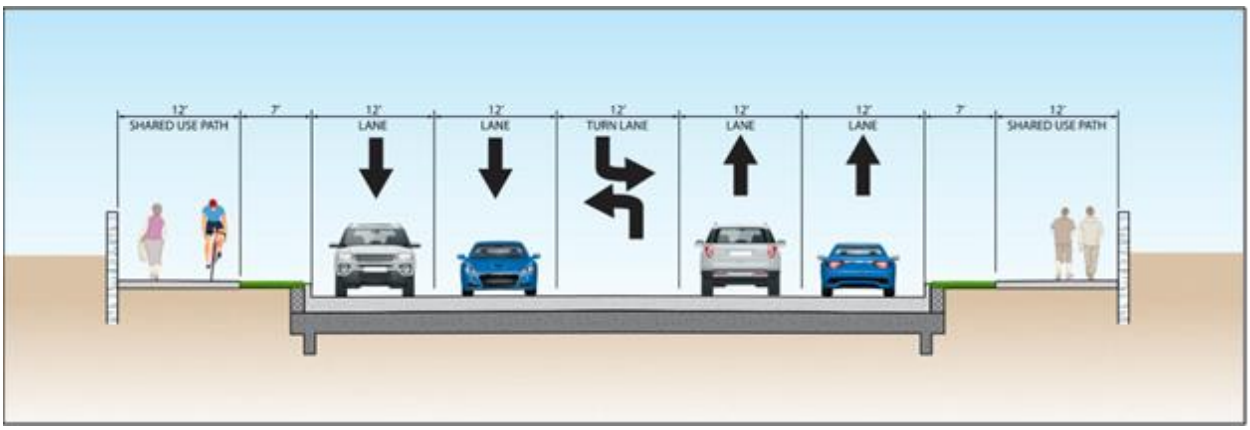

Figure 4: Proposed Typical Section, W. 81st Street

Base Case and Alternative

The Base Case for the Project is defined as the "No Build" scenario. This scenario reflects no capital improvements within the project limits but would require certain maintenance and rehabilitation cost for both US-75 and W. 81st Street over the analysis period.

The Alternative Case is defined as the Build scenario as described in the Project Description section above.

Types of Impacts

The proposed Project is expected to have the following impacts:

- Reduction in travel times for automobiles and trucks from faster travel times and reduced delays at surrounding intersections,
- Reduction in vehicle operating costs due to reduced fuel used during intersection delays,
- Improved vehicle safety due to new diverging diamond interchange,
- Improved pedestrian comfort and safety due to new sidewalks,
- Improved mobility for pedestrians and cyclists (with reduced distances and walk/cycling times),
- Reduction in emissions due to reduced travel distances, faster driving speeds, and reduced time spent idling during intersection delays,
- Reduced potential damages from bridge hits on low clearance US 75 bridges, and
- Increased useful life of the US-75 bridges.

Project Cost and Schedule – Alternative Case

Total project capital development and construction costs are estimated at $24.2 million based on the year that each cost estimate (construction, utilities, right-of-way, and design) was developed. For this BCA, these costs were adjusted to 2021 dollars using a GDP deflator[4]. The adjusted project development and construction cost amounts then to $21.8 million in 2021 undiscounted dollars and $15.8 million discounted at 7 percent. Project construction is anticipated to start in 2025 and take two years with completion by end of 2026. Therefore, 2027 is assumed as the Project opening year and first year of Project-related benefits. The Project will require major maintenance rehabilitation in 2027 estimated at $ $315,800k (2021 dollars).

Project Cost – Base Case

The Base Case (No Build) assumes no capital development or construction. However, the Base Case would require continued major maintenance rehabilitation in 2030, 2035 and 2045 estimated at $1.6 million, $1.0 million and $1.6 million (year of expenditure dollars), respectively. In 2021 dollars, the total major maintenance rehabilitation costs required are estimated at about $3.8 million undiscounted and $1.4 million discounted at 7 percent.

While the Alternative Case has maintenance costs associated with the project lifecycle planning, it is less than what would be incurred under the Base Case. Thus, the Alternative case creates a net savings in maintenance costs. **Table 3** provides a summary of costs.

[4] The adjustment applied a factor to costs in 2018, 2022 and 2023 dollars using the GDP deflator for each of the years that were 1.08, 0.90, and 0.85, respectively (Office of Management and Budget of the White House, Table 10.1, https://www.whitehouse.gov/omb/historical-tables/) (accessed Feb 16, 2023).

Table 3: Summary of Project Costs, Millions of Dollars in 2021

Cost Category	Undiscounted	Present Value at 3% Discount Rate	Present Value at 7% Discount Rate
Capital Cost	21.5	18.8	15.8
Maintenance (negative is savings)	-3.5	-2.2	-1.2
Total	**18.0**	**16.7**	**14.6**

Alignment with Selection Criteria

The main benefit categories associated with the project are mapped into the merit criteria set forth by U.S. DOT in **Table 4** below.

Table 4: Benefit Categories of the US-75/W. 81st Street Interchange Project

Criteria	Benefit(s)	Description	Monetized	Qualitative
Safety	Increased vehicle safety	DDI is expected to reduce collisions and fatalities.	Yes	Yes
	Added pedestrian comfort and safety	The new sidewalks will provide a safe environment for pedestrians.	Yes	Yes
Environmental Sustainability	Emissions reduction	The DDI is expected to reduce congestion and travel times which would reduce the amount of idling time	Yes	Yes
Quality of Life	Pedestrian access	Sidewalk access will be extended to improve pedestrian circulation	Yes	Yes
Mobility and Community Connectivity	Multi-path connection	The proposed design would include connections for cyclists and sidewalks for pedestrians to easily travel along the interchange.	No	Yes
Economic Competitiveness and Opportunity	Contribution to local economic development and growth	Increased access to adjacent development will increase economic impact of mixed used real estate	No	Yes
	Travel time savings	Travel time reliability will increase the efficiency and movement of the goods and people surrounding the project.	Yes	Yes
State of Good Repair	Reduced O&M Cost	Bridge replacement will reduce O&M	Yes	Yes
	Residual Value	Useful life of interchange will be extended	Yes	Yes
	Reduced bridge hits / damages	The new vertical clearance of the proposed bridges is expected to reduce bridge-vehicle collisions.	Yes	Yes
Partnership and Collaboration	ODOT and COT Collaboration	Project advancements and coordination have already been established allowing for a	No	Yes

		smooth transition into design and letting of the future project		
Innovation	DDI	Implement innovative geometry	No	Yes
	Use of New Technologies	The use of 3D models, GPS controlled equipment, and E-construction methods will be utilized in the implementation of this project.	No	Yes

General Assumptions

The BCA measures benefits against costs throughout a period of analysis beginning at the start of construction and including 20 years of operations. The methodology makes several important assumptions and seeks to avoid overestimation of benefits and underestimation of costs. Specifically:

- Input prices, costs, and benefits are expressed in 2021 dollars.
- The period of analysis begins in 2024 and ends in 2046. It includes three years of project development and construction in 2024 - 2026 and 20 years of operations (2027 – 2046).
- A constant 7 percent real discount rate is assumed throughout the period of analysis. except for benefits impacts related to CO_2 greenhouse (GHG) emissions which are discounted at a 3 percent real discount rate.
- Opening year demand and benefits are inputs to the BCA and are assumed to be fully realized after construction is finished and project starts operations in 2027 (no ramp-up).

Delay Forecasts and Pedestrian Counts

The delay forecast is a critical component of the benefit-cost analysis as multiple benefits depend on the vehicle delays using the Project area roads under No-Build and Build scenarios. Travel time savings for vehicles, travel time savings for pedestrians and emission reductions are all directly correlated with delay and pedestrian counts. Current and future delays were established for vehicular traffic as shown below in **Table 5**. Pedestrian counts near W. 81st and US-75 are provided in **Table 6**.

Table 5: Vehicle Hours of Delay, 2023 and 2046

Synchro Analysis: Total Vehicle-Hours per Day	2023		2046	
	AM	PM	AM	PM
Existing	47	44	179	249
Proposed	27	32	85	145
Benefit	20	12	94	104

Source: ODOT Design Traffic Data and Synchro Analysis

Table 6: Pedestrian Counts

Pedestrian Counts	
Year of Count	2023
Average Ped/day	68.5

Source: INCOG Count Data, January 2023

Benefits

This section describes the measurement approach used for each quantifiable benefit or impact category identified in **Table 4** and provides an overview of the methodologies and assumptions. A summary of all benefits is presented in **Table 7**.

Table 7: Summary of Benefits, Millions of Dollars in 2021

Project Evaluation Metric	Undiscounted	Present Value at 3% Discount Rate	Present Value at 7% Discount Rate
Safety Benefits	$4.15	$2.62	$1.51
Travel Time	$50.51	$31.30	$17.62
Reduced Vehicle Operating Costs	$2.13	$1.29	$0.70
Emissions Reduction*	$0.21	$0.13	$0.07
Pedestrian / Cycling Improvements	$2.18	$1.39	$0.82
Reduced Bridge Hits	$0.03	$0.02	$0.01
Residual Value	$5.05	$2.41	$0.93
Present Value of Benefit (Cost)	**$64.27**	**$39.17**	**$21.66**

Safety Benefits

Quantified safety benefits include reduction in expected number of crashes due to safer interchange configuration through the DDI. Using a Crash Modification Factor (CMF) approach, the *Federal Highway Administration DDI Informational Guide 2nd Edition* (NCHRP Report 959) provides a CMF of 0.434. This rate is expected to reduce total crashes during the analysis period from 98 total crashes to 43 total crashes under the Build alternative. The assumptions used in the estimation of safety benefits are summarized in **Table 8** below.

Table 8: Safety Assumptions

Variable	Unit	Value
Non-incapacitating injuries or possible injury	Incidents/year	1.78
PDO	Incidents/year	2.00
Total Crashes	Incidents/year	3.78
Base Year	year	2021
Non-incapacitating injuries or possible injury	$/incident	$153,700
PDO	$/incident	$4,800

Source: ODOT Collision Data, 2012-2021 and USDOT BCA Guidance for Discretionary Grant Programs

Travel Time Savings

The Project has two forms of travel time savings; reduced vehicle delay and reduced pedestrian travel time. The vehicle delays under the No-Build scenario, as shown in **Table 5**, amount to 91 vehicles hours of delay per day in 2023 and are forecast to increase to 428 vehicle hours of delay per day by 2046. The Project would reduce delays to 59 vehicles hours of delay per day in 2023 and 230 vehicle hours of delay per day in 2046, thus creating a savings of 32 and 198 vehicle-hours per day in 2023 and 2046, respectively. The assumptions used in the estimation travel time savings for vehicles are summarized in **Table 9** below.

Table 9: Travel Time Saving Assumptions - Vehicles

Variable	Unit	Value
All Purposes	$/person/hour	$18.80
Passenger Vehicles All Travel	Per vehicle	1.67

Source: USDOT BCA Guidance for Discretionary Grant Programs

The pedestrian time savings are significant for the project due to the 3.9-mile pedestrian path that exists currently to cross US-75. The current pedestrian path shown in **Figure 5** requires pedestrians utilize S. Elwood Ave, W. 91st Street, and S. Union Avenue to cross US-75. This is because there are no pedestrian facilities available on W. 81st in the vicinity of the Project. The Project pedestrian path will be approximately 0.3 miles which reduces 3.6 miles of travel time per pedestrian.

The total travel time of savings of $17.6 million, discounted at 7%, is comprised of approximately 66% vehicle travel time savings and 34% pedestrian time savings. The assumptions used in the estimation travel time savings for pedestrians are summarized in **Table 10** below.

Table 10: Travel Time Saving Assumptions - Pedestrian

Variable	Unit	Value
Current ped path length	miles	3.90
Proposed ped path length	miles	0.27
Pedestrian Speed	miles per hour	3.20
Value of time for pedestrian travel	$/person/hr	$34.00

Source: 60% design plans and USDOT BCA Guidance for Discretionary Grant Programs

Figure 5: Existing Pedestrian Path to Cross US-75 from W. 81st Street

Reduced Vehicle Operating Costs

While the Project will not reduce total vehicle miles traveled, it will reduce total vehicle delay, which in turn reduces fuel consumption. The SYNCHRO analysis provided total fuel consumption (gallons/day). Total gallons were monetized[5] with calculations provided within the BCA model. The total value of reduced vehicle operating cost through reduced fuel consumption equates to $0.7 million, discounted at 7%. **Table 11** summarizes these benefits.

[5] Based on values provided by Energy Information Administration: Energy Outlook, March 2022

Table 11: Estimated Fuel Consumption Savings (gal.), 2023 and 2046

Synchro Analysis: Fuel Consumption (gal.)	2023		2046	
	AM		AM	
Existing	116	114	253	308
Proposed	94	102	174	225
Benefit	22	12	79	83

Source: ODOT Design Traffic Data, Synchro Modeling, 60% design plans

Emissions Reduction

Similar to reduced vehicle operating costs, all emissions reductions will be achieved by the Project through reduced delay since total vehicle miles remain unchanged. The Project's DDI increases overall mobility which reduces the time vehicles are idling due to delays. The SYNCHRO analysis provided total kilogram (kg) of emissions per day for carbon dioxide (CO_2), nitrogen oxide (NO_X) and volatile organic compounds (VOC); however, only CO_2 and NO_X were monetized for the BCA. Total emissions are shown in **Table 12** below.

Table 12: Anticipated Emissions Reduction

Emissions (kg)	2023				2046			
	AM		PM		AM		PM	
	Existing	Proposed	Existing	Proposed	Existing	Proposed	Existing	Proposed
CO_2	8.08	6.6	7.97	7.13	17.7	12.19	21.54	15.74
NO_X	1.57	1.28	1.55	1.39	3.44	2.37	4.19	3.06
VOC	1.87	1.53	1.85	1.65	4.1	2.83	4.99	3.64

Source: ODOT Design Traffic Data, Synchro Modeling

The benefit associated with emissions reductions totals to $70,000, discounted at 7%, except for CO_2 which was discounted at 3% per USDOT BCA Guidelines because greenhouse gas (GHG) emissions can have long-lasting, even intergenerational impacts.

Pedestrian Improvements

The existing roadway within the Project corridor lacks pedestrian amenities including sidewalks, dedicated crosswalks and pedestrian signalized intersections. The additional amenities proposed by the Project will improve the quality or comfort of journeys made through forms of active transportation. Since there are no pedestrian facilities today, any such facilities proposed by the Project are a direct benefit. The assumptions related to pedestrian improvements are provided in **Table 13** below. The benefit associated with increased pedestrian facilities totals to $0.8 million, discounted at 7%.

Table 13: Pedestrian Amenities

Variable	Unit	Value
Proposed Sidewalk Width	feet	12.0
Number of Marked-Crosswalks	each	8
Number of Signals for Pedestrian Crossing	each	4
Sidewalk length	miles	0.53

Source: ODOT 60% design plans

Reduced Bridge Hits

The Project will replace the existing US-75 bridges that pass over W. 81st Street. The existing bridges have insufficient vertical clearance (14'7") and more subject to vehicle hits. The Project would replace the bridges with 17' high bridges to meet today's standards.

ODOT provided data related the damage incurred for low bridges throughout the State. This analysis focused on probability and average damage incurred within ODOT District 8 where the Project is located. Based on the assumptions provided in **Table 14** below, the Project would eliminate the risk of bridge hits which translates to a benefit of $11,000, discounted at 7%.

Table 14: Bridge Hit Reduction

Variable	Unit	Value
Number of Bridge Hits in District 8	count	10
Period of Bridge Hits Analyzed	years	4
Number of Low Clearance Bridge in District 8	count	276
Probability of Bridge Hit	incidents / Period	3.62%
Probability of Bridge Hit	incidents / year	0.91%
Bridge Replacement Cost	$	$ -
Average bridge damage per hit	$	$ 165,985
Total cost of bridge hit	$ / incident	$ 165,985

Source: ODOT

Residual Value

The residual value of project assets was calculated assuming a straight-line depreciation and a design life of 75 years for the bridge structures. No other project components were assumed to have any remaining useful life at the end of the analysis period. Under the No Build scenario, the existing bridges would not have any remaining useful life in 2046. The residual value was added to project benefits in the last year of the analysis period, 2046. Related assumptions are provided in **Table 15** below.

Table 15: Residual Value

Variable	Unit	Value
Residual Life (Project Bridge Cost)	$	$ 6,884,325
Useful Life	Years	75
Existing Asset Useful Value	$	$ -

Source: ODOT

BCA Sensitivity Analysis

The BCA outcomes presented in the previous sections rely on many assumptions and long-term projections, both of which are subject to considerable uncertainty. The primary purpose of the sensitivity analysis is to help identify the "critical variables"—the variables and model parameters whose variations have the greatest impact on the BCA outcomes.

The sensitivity analysis can also be used to:

- Evaluate the impact of changes in individual critical variables—how much the final results would vary with reasonable departures from the "preferred" or most likely value for the variable, and
- Assess the robustness of the BCA and evaluate whether the conclusions reached under the "preferred" set of input values are significantly altered by reasonable departures from those values.

The sensitivity analysis was conducted with respect to changes in the vehicle delay, pedestrian growth rate, value of CMF, capital cost, as well as years of operations included in Project BCA analysis. The outcomes of the analysis are summarized in **Table 16** below. The table provides the percentage changes in project NPV associated with variations in variables or parameters.

Table 16: BCA Sensitivity Analysis

Parameters	Change in Parameter Value	New NPV	% Change in NPV	New B/C Ratio
Vehicle Delay	20% Reduction	$ 5.35	-24.0%	1.37
	20% Increase	$ 8.73	24.0%	1.60
Pedestrian Growth Rate	20% Reduction	$ 5.35	-24.0%	1.37
	20% Increase	$ 8.73	24.0%	1.60
CMF	20% Reduction	$ 6.81	-3.3%	1.47
	20% Increase	$ 7.27	3.3%	1.50
Capital Cost	20% Reduction	$ 9.97	-41.6%	1.85
	20% Increase	$ 4.11	41.6%	1.23
Analysis Period	30 Year Analysis Period	$ 12.20	73.2%	1.83

The table demonstrates that under the alternative parameter values that may depress Project NPV, the Project maintains NPV above zero and BC Ratio of 1.23 or higher. When the number of years of Project operations is increased from 20 to 30, Project NPV increases by 73 percent to $12.2 million and the BC ratio increases to 1.83.