APPENDIX A:

BENEFIT COST ANAYLSIS TECHNICAL MEMORANDUM

2019 BUILD GRANT APPLICATION

COUNTY LINE MULTI-MODAL CORRIDOR OVERPASS PROJECT

Submitted by:

BROKEN ARROW
Where opportunity lives

JULY 15, 2019

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EXECUTIVE SUMMARY

A benefit-cost analysis (BCA) was conducted for the County Line Multi-Modal Corridor Overpass Project (the Project) for submission to the U.S. Department of Transportation (USDOT) as a requirement of a discretionary grant application for the FY 2019 BUILD grant program. The project will undertake the following activities, to alleviate congestion, promote safety, and improve multi-modal connectivity to support the region's economic vitality:

- Street reconstruction, including street widening to accommodate increased traffic,
- Bridge replacement, since the existing bridge is functionally obsolete,
- Bridge widening, since it does not currently have a shoulder,
- Bridge multimodal connectivity to school and neighborhoods,
- Multi-use trail extension, and
- Construction of Americans with Disabilities Act (ADA) compliant sidewalks and ramps.

Table E-1 describes the project benefits as they satisfy the criteria of the BUILD program.

Table E-1. *Project Benefits*

Merit Criteria	Project Benefits	Quantified Benefits (Millions)
Safety	The Project will improve safety for vehicular travelers, pedestrians and bicyclists. The center left turn lanes will reduce rear end collisions. The bicycle trail will remove bicyclists from the travel lane and from conflict with motorized vehicles. Installing a sidewalk will remove pedestrians from the travel way. Revised horizontal and vertical alignments provided by the Project will also improve safety along the corridor by increasing sight distances.	**Crash Reduction Benefits**: $4.5 discounted @ 7% ($11.2 undiscounted)
State of Good Repair	Replacing the roadway and bridge will reduce maintenance cost in the corridor. The new assets will have an extended design life compared to the existing assets. The new bridge will have a design life of 50 years with minimal maintenance. The pavement will have a design life of 20 years with minimal maintenance.	**Reduced Agency R&R**: $1.8 discounted @ 7% ($3.9 undiscounted) **Residual Value of the Bridge**: $0.5 discounted @ 7% ($2.7 undiscounted)
Economic Competitiveness	The roadway and bridge improvements will improve flow of traffic along County Line Road and SH-51. These critical links will enable the movement of goods and services through the corridor. Higher, more efficient average speeds will also result in reduced fuel costs.	**Time Travel Savings**: $12.9 discounted @ 7% ($35.0 undiscounted) **Fuel Cost Savings**: $0.9 discounted @7% ($2.4 undiscounted)
Environmental Sustainability	Improved flow of traffic will reduce idling, including the left turn lane, which will reduce greenhouse emissions and localized tail-pipe pollutants.	**Reduced Emissions**: $0.4 discounted at 7% ($0.7 undiscounted)
Quality of Life	The larger right of way will enable more efficient movement for vehicle/truck traffic, pedestrians, bicyclists, and emergency vehicles. Improved movement will improve access to healthcare, educational, and recreational facilities.	Unquantified

The benefits are compared to the total costs of the project, which only include capital costs (construction and previously incurred planning costs), these costs are summarized in **Table E-2**. The change in lifetime rehabilitation and repair (R&R) costs are included as a benefit; there is no change in the annual operating and maintenance (O&M) costs of the corridor as a result of the Project.

***Table E-2**. Total Project Costs (2017$ Millions)*

Type of Cost	Undiscounted	Discounted @ 7%
Capital Costs (above No-Build scenario)	$20.2	$16.3

The results of the BCA are shown in **Table E-3.** At a discount rate of 7 percent, the Project yields total benefits of $21.1 million and total costs of $16.3 million, for a Benefit Cost Ratio (BCR) of 1.3, a Net Present Value (NPV) of $4.8 million, and an Internal Rate of Return (IRR) of 10.

***Table E-3**. BCA Results*

BCA Metric	Undiscounted	Discounted @ 7%
Costs		
Capital Costs (above No-Build scenario)	$20.2	$16.3
Evaluated Benefits		
Accident Cost Reduction	$11.2	$4.5
Reduced Agency R&R Costs	$3.9	$1.8
Residual Value	$2.7	$0.5
Travel Time Savings	$35.0	$12.9
Fuel Cost Savings	$2.4	$0.9
Emissions Reduction	$0.7	$0.4
Total Evaluated Benefits	**$55.9**	**$21.1**
Net Present Value (NPV)	**$35.7**	**$4.8**
Benefit Cost Ratio (BCR)	**2.8**	**1.3**
Internal Rate of Return (IRR)	**10%**	**N/A**

1. INTRODUCTION

1.1. BCA Framework

A Benefit Cost Analysis (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. A BCA framework attempts to capture the net welfare change created by a project, including cost savings and increases in welfare (benefits), as well as 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 Base 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 lifecycle. 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 United States Department of Transportation (USDOT) in the Benefit-Cost Analysis Guidance for Discretionary Grant Programs, released in December 2018. This methodology includes the following analytical assumptions:

- Defining existing and future conditions under a No-Build base case as well as under the Build Case;
- Estimating benefits and costs during project construction and operation, including 30 years of operations beyond project completion when benefits accrue;
- Using USDOT recommended monetized values for reduced fatalities, injuries, property damage, travel time savings, and emissions, while relying on best practices for monetization of other benefits;
- Presenting dollar values in real 2017 dollars. In instances where cost estimates and benefits valuations are expressed in historical dollar years, using an appropriate Consumer Price Index (CPI) to adjust the values; and
- Discounting future benefits and costs with real discount rates of 7 percent, consistent with USDOT guidance.

1.2. Report Contents

Section 2 of the BCA Technical Memorandum contains a description of the County Line Multi-Modal Corridor Overpass Project (the Project) elements and information on the general assumptions made in the analysis. Section 3 provides a summary of the anticipated project costs. Section 4 reviews the expected economic benefits the Project would generate, including a review of the assumptions and methodology used to calculate the benefits. Finally, Section 5 reports the summarized results of the BCA.

2. PROJECT OVERVIEW

2.1. Description

The City of Broken Arrow, Oklahoma (OK) is requesting $5.60 million in Better Utilizing Infrastructure to Leverage Development (BUILD) funding for the $19.53 million County Line Multi-Modal Corridor Overpass Project (the Project).

The Project will improve safety, reduce congestion, and improve the flow of people and goods to urban and rural areas along the County Line Road corridor in Broken Arrow. It will generate a multitude of benefits along the corridor, including improved safety to motorists, pedestrians and bicyclists, reduced traffic congestion, improved air quality in the Tulsa Metropolitan Area, and enhanced access for urban and rural communities to jobs, and bolstered economic opportunities for existing and future commercial and industrial businesses located along the corridor.

The project location is a one-mile arterial street - County Line Road - and a bridge spanning SH-51. Both the street and the bridge are in need of several structural improvements, which include:

- Street reconstruction, including street widening to accommodate increased traffic,
- Bridge replacement, since the existing bridge is functionally obsolete,
- Bridge widening, since it does not currently have a shoulder,
- Bridge multimodal connectivity to school and neighborhoods,
- Multi-use trail extension, and
- Construction of Americans with Disabilities Act (ADA) compliant sidewalks and ramps.

The Project compliments approximately $25 million of state and local investment in street and highway rehabilitation and widening projects within the immediate corridor region. This additional investment by Broken Arrow and Oklahoma Department of Transportation (ODOT) exemplifies both the need to revitalize the corridor for local residents, and the dedication and partnership of local groups and public agencies to realize the necessary results.

2.2. Assumptions

Dollar figures in this analysis are expressed in constant 2017 dollars (2017$). For instances in which certain cost estimates or benefit valuations were expressed in dollar values in historical or future years, the values were deflated or inflated using adjustment factors based on the Bureau of Economic Analysis' National Income and Product Accounts, in line with USDOT Guidance.

The real discount rate used for this analysis was 7.0 percent, consistent with USDOT guidance for discretionary grants and OMB Circular A-94.

3. PROJECT COSTS

The only costs reflected in the Project's BCA are the capital costs of construction as well as the costs that have already been incurred to support development of plans, specifications, and estimates (PS&E). Under a No-Build scenario, the PS&E costs have already been incurred, but USDOT's guidance is to include previously incurred costs in the benefit-cost ratio (BCR). In the No-Build scenario, the capital costs of construction would not be incurred. The total capital costs of the Project amount to $16.3 million (discounted at 7 percent).

3.1. Capital Costs

The costs of construction amount to $18.9 million (undiscounted); construction will occur between FFY2020 and FFY2023. The capital construction costs include: the cost to construct the roadway ($10.6 million, undiscounted) and the cost to construct the bridge ($4.6 million, undiscounted) in addition to a 15 percent contingency and a 10 percent management and inspection cost. The PS&E costs ($1.3 million, undiscounted) were incurred in FY 2018, Table 3-1 provides a detailed capital cost schedule of how costs actually were incurred (therefore PS&E costs are shown in FY 2018). Note that this schedule is in 2017 dollars, so numbers will be slightly lower than what is presented in the narrative. Additionally note, for the purpose of the BCA (to be consistent with USDOT's guidance), these costs are applied to the first year of the Project analysis period, FY 2020

Table 3-1. *Capital Costs (Millions, undiscounted)*

Costs	FY2018	FY2019	FY2020	FY2021	FY2022	FY2023	Total
Construction Expenses							
Construction of Roadway	$ -	$ -	$1.5	$5.1	$2.9	$1.08	$10.6
Construction of Bridge	$ -	$ -	$0.7	$2.2	$1.7	$ -	$4.6
Contingency, 15%	$ -	$ -	$0.3	$1.1	$0.7	$0.2	$2.3
Construction Management & Inspection, 10%	$ -	$ -	$0.2	$0.7	$0.5	$0.1	$1.5
Total Cost of Construction	**$ -**	**$ -**	**$2.7**	**$9.1**	**$5.8**	**$1.4**	**$18.9**
Previously Incurred Costs							
PS&E Costs	$1.3	$ -	$ -	$ -	$ -	$ -	$ -
Total Capital Costs	**$1.3**	**$ -**	**$2.7**	**$9.1**	**$7.1**	**$1.4**	**$20.2**

The total capital costs of the Project amount to $16.3 million (discounted at 7 percent), as shown in Table 3-2.

Table 3-2*. Total Capital Costs (Millions)*

	Undiscounted	Discounted (7%)
Total Capital Costs	$20.2	$16.3

3.2. Operating and Maintenance Costs

Operating and maintenance (O&M) costs are not expected to differ between the Build and No-Build scenarios, and therefore are not included in the BCA.

3.3. Rehabilitation and Repair Costs

Under the Build scenario, there are no rehabilitation and repair (R&R) costs. However, there are R&R costs associated with the No-Build scenario for the cost of overlays for the road, which are only needed to maintain a state of good repair if the Project does not take place. Elimination of R&R costs is considered a benefit of the Project and is covered in more detail in section 4.2.

4. PROJECT BENEFITS

The key benefits of Project include address safety (crash reductions), state of good repair (reduced R&R costs and residual value of the bridge), economic competitiveness (time and fuel savings), and environmental sustainability. The wider roadway will reduce crashes which will result in safety benefits. From a state of good repair perspective, the Project will eliminate the need for four overlays during the analysis period. Additionally, the City of Broken Arrow will realize benefits from the residual value of the bridge, as its design life extends past the end of the analysis period. The new roadway will be wider and less curvy, allowing for the speed limit to be safely raised from 40 mph to 45 mph and overall travel speeds to increase, resulting in travel time savings, fuel savings, and reduced emissions.

4.1. Safety

The Project will improve safety for vehicular travelers, pedestrians and bicyclists. The center left turn lanes will reduce rear end collisions. The bicycle trail will remove bicyclists from the travel lane and from conflict with motorized vehicles. Installing a sidewalk will remove pedestrians from the travel way. Revised horizontal and vertical alignments provided by the Project will also improve safety along the corridor by increasing sight distances.

Safety benefits of the Project are expected as a result of widening the highway from two to five lanes. A study from the Texas Transportation Institute at Texas A&M, "Comparisons of Crashes on Rural Two-Lane and Four-Lane Highways in Texas" supported a 20 percent crash reduction as a result of the roadway widening (for an undivided roadway). As a result, the Project anticipates $4.5 million (discounted at seven percent) in safety benefits due to accident reductions, which amounts to approximately 12 fewer accidents per year.

Crash Reduction

Anticipated Crash Reduction

Table 4-1 summarizes the roadway's historical KABCO rates from 2013 to 2017. The BCA assumes that the accident reduction as a result of the Project will be equal to 20 percent crash reduction based on the average number of crashes from 2013 to 2017.

Table 4-1. *Historical KABCO Rates (2013 – 2017)*

Crash Type	2013	2014	2015	2016	2017	Average
Killed	0	0	0	0	0	0
Incapacitating	3	1	0	1	0	1
Non-Incapacitating	12	4	10	11	9	9
Possible Injury	11	9	12	20	19	14
No Injury	29	46	31	45	35	37
Total	55	69	53	77	63	62

Table 4-2 summarizes the expected annual number of crash reductions as a result of the Project. Based on the 20 percent crash reduction factor, the Build scenario is expected to reduce annual crashes by 12.

***Table 4-2**. Crash Reductions*

Crash Type	Average	Reduction
Killed	0	0
Incapacitating	1	0
Non-Incapacitating	9	2
Possible Injury	14	3
No Injury	37	7
Total	62	12

Safety Assumptions

Table 4-3 provides the safety benefits assumptions recommended by US DOT.

***Table 4-3**. Safety Benefits Assumptions and Sources*

Variable	Unit	Value	Source
Killed	2017$	$9,600,000	US DOT Guidance
Incapacitating	2017$	$459,100	US DOT Guidance
Non-Incapacitating	2017$	$125,000	US DOT Guidance
Possible Injury	2017$	$63,900	US DOT Guidance
No Injury	2017$	$3.200	US DOT Guidance

Safety Results

Table 4-4 summarizes the safety benefits of the Project. Injury reduction benefits will amount to $4.3 million (discounted 7 percent) and property damage reduction will amount to $0.3 million (discounted 7 percent). The total safety benefits of the Project would be $4.5 million (discounted 7 percent).

***Table 4-4**. Safety Benefit Results (Millions)*

Benefit	Undiscounted	Discounted (7%)
Injury Reduction	$10.6	$4.3
Property Damage Reduction	$0.7	$0.3
Total Safety Incident Reduction	$11.2	$4.5

4.2. State of Good Repair

Replacing the roadway and bridge will reduce maintenance cost in the corridor. The new assets will have an extended design life compared to the existing assets. The new bridge will have a design life of 50 years with minimal maintenance. The pavement will have a design life of 20 years with minimal maintenance

Reduced R&R Costs

In the No-Build scenario, the City of Broken Arrow will need to do an overlay of the road in FY 2020, FY 2027, FY 2034, and FY 2041, which would cost $0.5 million, $1.5 million, $1.5 million, and $0.5 million (undiscounted), respectively. Table 4-5 summarizes the anticipated overlay costs of the No-Build scenario. Note that there is no notable difference between O&M costs in the Build and No-Build scenarios.

***Table 4-5**. No-Build R&R Costs (Millions, undiscounted)*

Year	FY 2020	FY 2027	FY 2034	FY 2041
Overlay Cost – No-Build	$0.5	$1.5	$1.5	$0.5

However, if the Project takes place according to the proposed schedule, with construction commencing in FFY 2020 and ending in FFY 2022, there will be no need for an overlay until the roadway has exceeded its useful life, in FY 2043. The analysis period considered for this project ends in FY 2042, the last year of the roadway's useful life.

Residual Value of the Bridge

Based on the expected life span and original value of the bridge, the residual value benefits of the bridge through the end of the project analysis period will be $0.5 million (discounted at seven percent).

Project Asset Characteristics

The design life of the roadway and bridge will be 20 years and 50 years, respectively. The original capital cost of the road and bridge are $10.6 million and $4.5 million, respectively. This information is summarized in Table 4-6.

***Table 4-6**. Project Asset Characteristics*

Asset	Expected Life Span	Capital Cost (Millions)	Last Purchase Year
Road	20	$10.6	2022
Bridge	50	$4.5	2022

Residual Value Assumptions

Per USDOT instruction, the Project analysis period is equal to the construction period (three years) plus the useful life of the roadway (20 years), for a total Project analysis period of 23 years (FY 2020 – FY 2042). At the end of the Project analysis period, the bridge will only be roughly halfway through its design life, therefore the City of Broken Arrow realizes the additional benefit of the residual value of the bridge.

State of Good Repair Benefits Results

As a result of the foregone overlay costs, the Project would generate $1.8 million (discounted at seven percent) in reduced R&R costs. The residual value benefits of the bridge through the end of the project analysis period will be $0.5 million (discounted at seven percent). This information is summarized in Table 4-7.

***Table 4-7**. SGR Benefits Results (Millions)*

Benefit	Undiscounted	Discounted (7%)
Change in R&R Costs	$3.9	$1.8
Residual Value - Bridge	$2.7	$0.5
Total SGR Benefits	$6.6	$2.3

4.3. Traffic Projections

The purpose of this section is to provide the methodology and assumptions underlying the traffic projections used to quantify the following benefits: travel time savings, fuel savings, and emissions reductions. Travel time savings and fuel savings result will be covered in section 4.4 (Economic Competitiveness) and emissions reductions will be covered in section 4.5 (Environmental Benefits).

Traffic projections were determined based on the traffic volume (vehicles per day) in 2018 and the projected traffic volume in 2045. The traffic volume rates were determined using StreetLight data, which takes the average over 365 days per year and therefore the traffic annualization factor was 365. Table 4-8 provides a summary of the traffic volume in 2018 (13,306 vehicles per day) and the projected traffic volume in 2045 (29,450 vehicles per day).

Table 4-8. *Traffic Volume*

Year	Traffic Volume (vehicles per day)	Source
2018	13,306	INCOG *
2045	29,450	INCOG *

* Indian Nations Council of Governments (INCOG)

The compounded annual growth rate (CAGR) based on these traffic volumes is 3.0 percent. This CAGR was used to project traffic volume through the analysis period, particularly for FY 2023 through FY 2042, the period during which the project would be operational and time savings would be realized by users.

Note that the traffic volume assumptions do not differ between the Build and No-Build scenarios, they are determined based on population and economic factors. StreetLight uses the Tulsa regional transportation model, which follows a four-step modeling process. An iterative, expert Delphi panel determines the land use projections based on population and employment distribution within the region. Additionally, the model is based on trip generation using the regional household survey results. The future year traffic assignment is completed using the validated model for the base year. The traffic projections utilize the initial land use projections, therefore the need for the roadway expansion is determined based on demand for capacity.

These assumptions resulted in the traffic volumes presented in Table 4-9.

Table 4-9. Traffic Volume Projections, FY 2018 – FY 2045

Fiscal Year	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Vehicles per Day	13,306	13,703	14,113	14,534	14,968	15,415	15,875	16,349	16,838	17,340	17,858	18,392	18,941	19,506
Vehicles per Year	4,856,690	5,001,722	5,151,085	5,304,909	5,463,326	5,626,473	5,794,493	5,967,530	6,145,735	6,329,261	6,518,267	6,712,918	6,913,381	7,119,831

Fiscal Year	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
Vehicles per Day	20,089	20,689	21,307	21,943	22,598	23,273	23,968	24,684	25,421	26,180	26,962	27,767	28,596	29,450
Vehicles per Year	7,332,446	7,551,410	7,776,913	8,009,149	8,248,321	8,494,635	8,748,305	9,009,550	9,278,596	9,555,677	9,841,032	10,134,908	10,437,560	10,749,250

Other Travel Assumptions

This section provides a summary of the other travel assumptions to determine the travel time savings for the following class of passengers:

- Automobile passengers, peak
- Automobile passengers, off peak
- Truck passengers, peak
- Truck passengers, off peak

Table 4-10 shows the distribution of automobiles vs. trucks based on current travel patterns.

Table 4-10. *Distribution between Automobile and Truck Travel*

Type of Vehicle	Distribution	Source
Automobiles	95%	INCOG
Trucks	5%	INCOG

Table 4-11 provides the distribution between peak vs. off peak based on current travel patterns.

Table 4-11*. Distribution between Peak and Off Peak Travel*

Time of Travel	Distribution	Source
Peak	20%	INCOG
Off Peak	80%	INCOG

Table 4-12 provides vehicle occupancy assumptions for automobiles and trucks during both peak and off-peak travel.

Table 4-12. *Vehicle Occupancy Automobiles and Trucks, Peak and Off Peak*

Type of Vehicle/Time	Vehicle Occupancy	Source
Automobiles, Peak	1.08	INCOG
Automobiles, Off Peak	1.24	INCOG
Trucks, Peak	1.00	USDOT
Trucks, Off Peak	1.00	USDOT

4.4. Economic Competitiveness

The roadway and bridge improvements will improve flow of traffic along County Line Road and SH-51. These critical links will enable the movement of goods and services through the corridor. Additionally, higher, more efficient average speeds will result in reduced fuel costs.

Travel Time Savings

Time savings benefits apply primarily to automobile and truck travel. Time savings benefits are two-fold for this Project; travelers during off-peak hours will realize time savings as a result of increased speed limits, and travelers during peak hour travel will realize additional savings as a result of the increased capacity of the roadway. Speed limit increases (from 40 mph to 45 mph) are possible from a safety perspective because the new roadway will be less curvy than the original roadway. Increased capacity is a result of widening the highway from two to five lanes.

Based on current speed patterns within the corridor, travelers would save 50 seconds per passenger per trip during peak hour travel and 30 seconds per passenger per trip during off-peak hour travel. The analysis concluded that the time savings benefits for this Project would be $12.9 million (discounted at seven percent).

Time Savings per Trip

Time savings per trip were computed based on speed profiles for the current roadway, which indicated an average speed of 27.5 mph during current peak hour conditions and 32.5 mph under current off peak hours.

If the project is completed, the roadway alignment will be straighter and the speed limit will be raised from 40 mph to 45 mph. The BCA assumes that currently, travelers are unable to drive at the posted speed limit because of the curvature of the road and the limited number of lanes, and that if the project is completed, travelers will be able to safely travel at 45 mph at all hours of the day.

Given that the roadway is 1 mile long, under current conditions, the average passenger takes approximately 2 minutes and 11 seconds per trip during peak hour travel and 1 minute and 51 seconds per trip during off peak travel. The travel time is expected to be reduced to 1 minute and 20 seconds per trip during both on and off peak travel as a result of the Project, resulting in a time savings of 51 seconds per passenger per trip during peak hour travel and 31 seconds per passenger per trip during off peak hour travel. Table 4-13 provides a summary of current peak and off peak travel speeds and travel times compared to anticipated travel speed and travel time as a result of the Project.

Table 4-13. *Comparison of Current and Expected Travel Characteristics*

	Current, Peak	Current, Off Peak	After Project Peak/Off Peak
Average speed (mph)	27.5	32.5	45
Travel time per passenger per trip (seconds)	131	111	80

Table 4-14 summarizes the total travel time saved for both automobiles and trucks.

Table 4-14. *Time Savings, by vehicle type and travel time (annual hours)*

Fiscal Year	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
Automobile, Peak	16,327	16,815	17,317	17,834	18,366	18,915	19,480	20,061	20,660	21,277	21,913	22,567	23,241	23,935	24,650	25,386	26,144	26,925	27,729	28,557
Automobile, Off Peak	45,320	46,673	48,067	49,502	50,980	52,503	54,071	55,685	57,348	59,061	60,824	62,641	64,511	66,438	68,422	70,465	72,569	74,736	76,968	79,267
Total Automobile	**61,647**	**63,487**	**65,383**	**67,336**	**69,347**	**71,418**	**73,550**	**75,747**	**78,009**	**80,338**	**82,737**	**85,208**	**87,752**	**90,373**	**93,072**	**95,851**	**98,713**	**101,661**	**104,697**	**107,823**
Truck, Peak	796	819	844	869	895	922	949	978	1,007	1,037	1,068	1,100	1,133	1,166	1,201	1,237	1,274	1,312	1,351	1,392
Truck, Off Peak	1,924	1,981	2,040	2,101	2,164	2,228	2,295	2,364	2,434	2,507	2,582	2,659	2,738	2,820	2,904	2,991	3,080	3,172	3,267	3,364
Total Truck	**2,719**	**2,800**	**2,884**	**2,970**	**3,059**	**3,150**	**3,244**	**3,341**	**3,441**	**3,544**	**3,650**	**3,759**	**3,871**	**3,986**	**4,105**	**4,228**	**4,354**	**4,484**	**4,618**	**4,756**

Table 4-15 provides a summary of assumptions used to determine the monetized value of travel time savings.

Table 4-15. *Value of Travel Time Savings, automobile and truck*

Variable	Unit	Value	Source
Value of Travel Time Savings - All Purposes, Local	2017$ per person hour	$16.10	USDOT Guidance, December 2018
Truck Drivers VTTS	2017$ per person hour	$28.60	USDOT Guidance, December 2018
Value of Travel Time - Real Growth Rate	Annual Rate	1.20%	USDOT Guidance, 2014

Fuel Savings

The new roadway will be straighter and wider, allowing users to safely travel at higher speeds. Vehicle miles traveled in the corridor are not expected to change between the Build and No-Build scenarios. As such, the project is expected to generate fuel savings benefits for drivers, as the slight increase in average speeds will be more fuel efficient than current speeds under the No-Build scenario.

The fuel cost savings associated with the Project would be $0.9 million (discounted at 7 percent), as a result of more efficient average travel speeds in the corridor.

Table 4-16 summarizes the assumptions used to compute fuel savings benefits.

Table 4-16*. Fuel Savings Assumptions*

Variable	Unit	Value	Source
Gasoline Costs	2017$ per gal incl. taxes	Range from $2.53 in 2019 to $3.67 in 2050	US EIA, "Annual Energy Outlook 2018," Table 12
Diesel Costs	2017$ per gal incl. taxes	Range from $2.78 in 2019 to $4.09 in 2050	US EIA, "Annual Energy Outlook 2018," Table 12
Federal Fuel Taxes	2019$	$0.184 for gasoline and $0.244 for diesel	API, "State Motor Fuel Taxes by State", January 2019
State of Oklahoma Fuel Taxes	2019$	$0.200 for gasoline and $0.200 for diesel	API, "State Motor Fuel Taxes by State", January 2019
Auto Fuel Efficiency	Miles per gal	Range from 23.67 in 2019 to 38.18 in 2050	US EIA, "Annual Energy Outlook 2018," Table 7
Truck Fuel Efficiency	Miles per gal	Range from 7.34 in 2019 to 10.45 in 2050	US EIA, "Annual Energy Outlook 2018," Table 7
Auto Fuel Efficiency Adjustment Factor	Factor	0.97 for the Build scenario (@ 45 mph) 1.12 for the No-Build scenario (@32 mph)	US EIA 2013
Truck Fuel Efficiency Factor	Factor	1.03 for the Build scenario (@45 mph) 1.15 for the No-Build scenario (@32 mph)	US EIA 2013

Economic Competitiveness Benefits Results

Table 4-17 summarizes the total travel time savings benefits of the Project. Automobile passenger travel time savings will amount to $12.0 million (discounted at 7 percent), truck passenger travel time savings will amount to $0.9 million (discounted at 7 percent), for a total travel time savings benefit of $12.9 million (discounted at 7 percent). Additionally, automobile fuel cost savings will be $0.8 million (discounted at 7 percent) and truck fuel cost savings will be $0.1 million (discounted at 7 percent), for total fuel cost savings of $0.9 million (discounted at 7 percent). Total economic competitiveness benefits will amount to $13.8 million (discounted at 7 percent).

***Table 4-17**. Economic Competitiveness Benefits, undiscounted and discounted (Millions)*

Benefit	Undiscounted	Discounted (7%)
Travel Time Savings – Automobile	$32.5	$12.0
Travel Time Savings – Truck	$2.6	$0.9
Total Travel Time Savings	$35.0	$12.9
Fuel Savings – Automobile	$2.0	$0.8
Fuel Savings – Truck	$0.3	$0.1
Total Fuel Savings	$2.4	$0.9
Total Economic Competitiveness Benefits	$37.4	$13.8

4.5. Environmental Benefits

Widening the roadway will result in improved traffic flow through the corridor, which will reduce idling, including the left turn lane, and reduce greenhouse emissions and localized tail-pipe pollutants. The Project is expected to generate $0.4 million (discounted at 7 percent) in reduced emissions as a result of alleviating congestion by increasing the capacity of the roadway.

Five forms of emissions were identified, measured and monetized, including: nitrous oxide, particulate matter, sulfur dioxide, volatile organic compounds, and carbon dioxide. The analysis assumes a given level of pollutant emissions are released for each vehicle mile traveled, and that these vary by whether the vehicle is an automobile or a truck, and also by the speed driven.

***Table 4-18**. Emission Benefits Assumptions*

Variable	Unit	Value	Source
Cost of CO_2 emissions	2017$ per metric ton	$1 through 2035, $2 thereafter	US DOT Guidance, Dec. 2018
Cost of NO_x emissions	2017$ per metric ton	$9,142.45*	US DOT Guidance, Dec. 2018
Cost of PM_{10} emissions	2017$ per metric ton	$416,146.70*	US DOT Guidance, Dec. 2018
Cost of SO_x emissions	2017$ per metric ton	$53,863.35*	US DOT Guidance, Dec. 2018
Cost of VOC emissions	2017$ per metric ton	$2,203.00*	US DOT Guidance, Dec. 2018
Emissions per VMT	Metric tons of emissions per VMT	Varies by year, fuel type, and emission type	California Air Resources Board EMFAC Database, 2017; EPA MOVES, 2014
Emissions Speed Adjustment Factors	Factor	Varies by year, fuel type, emission type, and speed	California Air Resources Board EMFAC Database, 2014

** Converted from values based on for short tons*

Environmental Benefits Summary

Table 4-19 summarizes the environmental benefits of the Project, which would amount to $0.4 million (discounted at 7 percent).

***Table 4-19**. Emissions benefits*

Benefit	Undiscounted	Discounted (7%)
CO_2 Emissions Reduction	$0.0	$0.0
NO_x Emissions Reduction	$0.8	$0.4
SO_x Emissions Reduction	$0.0	$0.0
PM Emissions Reduction	($0.1)	($0.0)
VOC Emissions Reduction	$0.0	$0.0
Total Emissions Reduction	$0.7	$0.4

5. SUMMARY OF RESULTS

5.1. Evaluation Measures

The BCA converts potential gains (benefits) and losses (costs) from 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.
- Payback Period: The payback period refers to the period of time required to recover the funds expended on a project.

5.2. BCA Results

Table 5-1 presents the evaluation results for the County Line Multi-Modal Corridor Overpass Project. Results are presented in undiscounted values, and discounted at 7 percent as prescribed by USDOT. All benefits and costs were estimated in constant 2017 dollars over an evaluation period of 23 years (three years for construction and 20 years for the design life of the road).

At a discount rate of 7 percent, the Project yields total benefits of $21.1 million and total costs of $16.3 million, for a NPV of $4.8 million, a BCR of 1.3, and an IRR of 10 percent.

Table 5-1. *BCA Results*

BCA Metric	Undiscounted	Discounted @ 7%
Costs		
Capital Costs (above No-Build scenario)	$20.2	$16.3
Evaluated Benefits		
Accident Cost Reduction	$11.2	$4.5
Reduced Agency R&R Costs	$3.9	$1.8
Residual Value	$2.7	$0.5
Travel Time Savings	$35.0	$12.9
Fuel Cost Savings	$2.4	$0.9
Emissions Reduction	$0.7	$0.4
Total Evaluated Benefits	**$55.9**	**$21.1**
NPV	**$35.7**	**$4.8**
BCR	**2.8**	**1.3**
IRR	**10%**	**N/A**