

# BCA TECHNICAL MEMORANDUM

## US Highway 412 Improvements for Interstate Designation Project Oklahoma Department of Transportation

### Executive Summary

Oklahoma Department of Transportation (ODOT) is seeking funding for the conversion of a 27-mile section of US Highway 412 (US-412) into an interstate. The \$130 million US-412 Improvements for Interstate Designation (the Project) would mean the addition of 14 grade separations, including eight new interchanges and six new overpasses; bridge modifications; resurfacing of existing structures; and the addition of new ramps.

The project significantly improves the safety savings due to the removal or reconfiguration of at-grade crossings. The fatal crash cost savings due to the various at-grade changes result in the largest positive cash flow for this project.

The **\$139.8 million** total capital project cost of the Program yields:

- **Benefit-cost ratio (BCR) of 1.71**
- **Internal rate of return of 5.02 percent**
- **Positive net user benefit of about \$138.2 million (NPV)** over 20 years, mostly from safety savings.

Over the life of the **PROJECT**, these investments will produce:

- |                              |                                                |
|------------------------------|------------------------------------------------|
| • <b>Safety Savings</b>      | <b>\$138.6 million net present value (NPV)</b> |
| • <b>Travel Time Savings</b> | <b>\$104.1 thousand (NPV)</b>                  |
| • <b>Maintenance Costs</b>   | <b>\$463.4 thousand (NPV)</b>                  |

### Methodology

The Benefit Cost Analysis (BCA) was prepared in accordance with the [2022 FHWA BCA Guidance for Discretionary Grant Programs](#) using total quantifiable project costs and benefits that are adjusted for inflation and then discounted to reflect the time value of money. In summary, the BCA was created by:

1. Identifying the Project's benefits and costs in terms of proposed improvements versus a no-build scenario;
2. Deriving current and forecasted use levels for the baseline and the "build case";
3. Denominating all benefits and costs in constant 2020 dollars;
4. Assuming inflation based on the Implicit Price Deflators for Gross Domestic Product;
5. Discounting dollar amounts by 7 percent to reflect the time value of money;
6. Emissions discounted at 3 percent rate; and
7. Setting an appropriate analysis period of 20 years for the Project's development, construction and subsequent operational service.

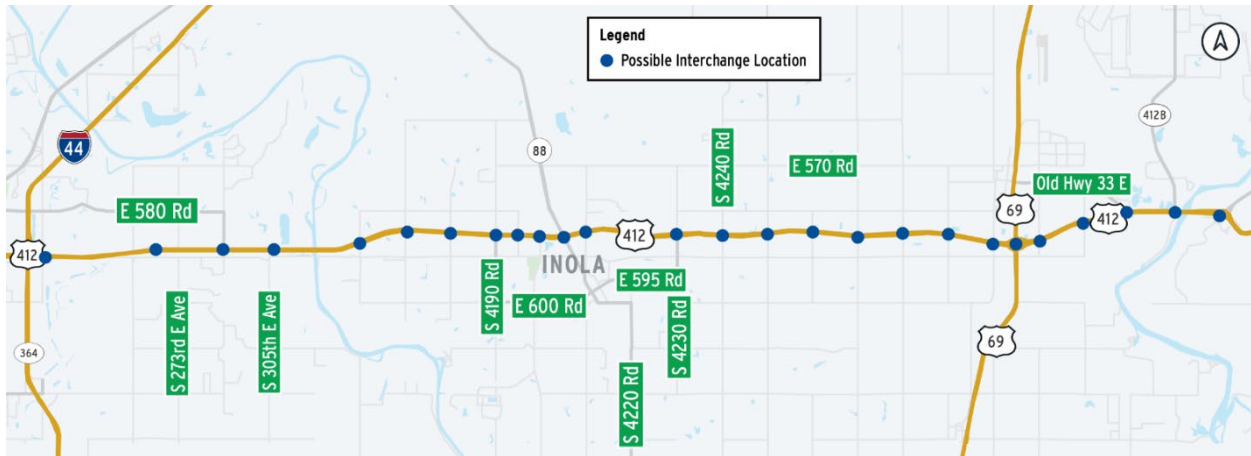
### Project Overview

The Project is the conversion of a 27-mile section of US Highway 412 (US-412) from I-44 to the Cherokee Turnpike which is part of a larger effort to improve US-412 to interstate standards ultimately connecting I-35 and I-49. The project area is shown in **Figure 1** on the following page. The existing US-412 is currently a high-speed corridor with a posted speed limits ranging from 65 mph to 70 mph. The existing Project corridor has at-grade intersections as well as four grade-separated interchanges/overpasses. Because access control is inconsistent for the entirety of US-412, drivers within the Project corridor can experience unsafe conditions including unexpected slowing and accelerating, passing and weaving, and dangerous access points. The points on **Figure 2** identify where access will need to be evaluated and improved to either an interchange, overpass or a cul-de-sac with no access.

Figure 1: Project Area



Figure 2: Locations for Possible Interchanges and Overpass



As mentioned previously, the project will have significant savings in safety due to the reduction of collisions. This is just one of the overall benefits identified from the BCA. **Table 1** outlines all of the proposed improvements that were evaluated by the BCA in a detailed spreadsheet to show the total of all benefits discounted at 7 percent with a 3 percent discount applied to CO<sub>2</sub> emissions.

**Table 1: Proposed Improvements**

20 Year BENEFITS										
Analysis Year	Operation and Maintenance Costs	Economic Competitiveness		Environmental		Safety	Total	7% Discount	3% Discount	Total Discount
		Travel Time Savings	Operational Savings	Reduced Pollutants (Nox & PM2.5)	Reduced Pollutants (CO2)	Crash Savings				
2020										
2021										
2022										
2023										
2024										
2025										
2026										
2027		\$12,454	\$0	\$0	\$0	\$15,243,678	\$15,256,132	\$9,500,752	\$0	\$9,500,752
2028		\$12,647	\$0	\$0	\$0	\$15,247,642	\$15,260,289	\$8,881,627	\$0	\$8,881,627
2029	(\$150,000)	\$12,845	\$0	\$0	\$0	\$15,324,225	\$15,187,070	\$8,260,760	\$0	\$8,260,760
2030	(\$85,000)	\$13,045	\$0	\$0	\$0	\$15,362,376	\$15,290,421	\$7,772,875	\$0	\$7,772,875
2031	\$0	\$13,249	\$0	\$0	\$0	\$15,368,486	\$15,381,735	\$7,307,751	\$0	\$7,307,751
2032	(\$85,000)	\$13,455	\$0	\$0	\$0	\$15,442,924	\$15,371,379	\$6,825,076	\$0	\$6,825,076
2033	(\$120,000)	\$13,665	\$0	\$0	\$0	\$20,857,128	\$20,750,793	\$8,610,841	\$0	\$8,610,841
2034	(\$85,000)	\$13,878	\$0	\$0	\$0	\$20,899,244	\$20,828,122	\$8,077,505	\$0	\$8,077,505
2035	\$0	\$14,095	\$0	\$0	\$0	\$21,232,440	\$21,246,535	\$7,700,722	\$0	\$7,700,722
2036	(\$85,000)	\$14,315	\$0	\$0	\$0	\$21,234,586	\$21,163,901	\$7,168,945	\$0	\$7,168,945
2037	\$0	\$14,537	\$0	\$0	\$0	\$21,276,702	\$21,291,239	\$6,740,261	\$0	\$6,740,261
2038	(\$205,000)	\$14,764	\$0	\$0	\$0	\$21,353,284	\$21,163,048	\$6,261,382	\$0	\$6,261,382
2039	\$0	\$14,994	\$0	\$0	\$0	\$21,357,249	\$21,372,243	\$5,909,603	\$0	\$5,909,603
2040	(\$85,000)	\$15,228	\$0	\$0	\$0	\$21,431,686	\$21,361,914	\$5,520,325	\$0	\$5,520,325
2041	\$0	\$15,466	\$0	\$0	\$0	\$21,473,802	\$21,489,268	\$5,189,939	\$0	\$5,189,939
2042	(\$85,000)	\$15,707	\$0	\$0	\$0	\$21,478,671	\$21,669,378	\$4,891,064	\$0	\$4,891,064
2043	(\$120,000)	\$15,952	\$0	\$0	\$0	\$21,849,114	\$21,745,066	\$4,587,054	\$0	\$4,587,054
2044	(\$85,000)	\$16,201	\$0	\$0	\$0	\$21,855,224	\$21,786,425	\$4,295,120	\$0	\$4,295,120
2045	\$0	\$16,453	\$0	\$0	\$0	\$21,931,807	\$21,948,260	\$4,043,949	\$0	\$4,043,949
2046	(\$85,000)	\$16,710	\$0	\$0	\$0	\$21,971,778	\$21,903,488	\$3,771,682	\$0	\$3,771,682
2047	\$0	\$16,971	\$0	\$0	\$0	\$22,048,360	\$22,065,331	\$3,550,982	\$0	\$3,550,982
2048	(\$205,000)	\$17,235	\$0	\$0	\$0	\$22,313,229	\$22,125,464	\$3,327,719	\$0	\$3,327,719
<b>Total</b>	<b>(\$1,480,000)</b>	<b>\$323,866</b>	<b>\$0</b>	<b>\$0</b>	<b>\$0</b>	<b>\$436,813,635</b>	<b>\$435,657,501</b>	<b>\$138,195,935</b>	<b>\$0</b>	<b>\$138,195,935</b>

Project Beneficiaries

The economic competitiveness category quantifies multiple benefits with its analysis. The benefits quantified represent the difference of the reduced collisions on US-412 through between I-44 and the Cherokee Turnpike. Benefits quantified are associated with the improvements associated with the interstate designation including the removal of all at-grade intersections.

## Project Benefits

The Project will provide substantial benefit by removing or reconstructing all at-grade intersections from the US-412 corridor. The benefits of the change in travel characteristics were quantified including reduced travel time and reduced safety costs.

The Benefit Cost Analysis was prepared for this project application in accordance with the [BCA Guidance for Discretionary Grant Programs dated March 2022](#). Calculations for all figures as well as the cited sources can be found within the BCA spreadsheets that are included with the INFRA grant submittal.

## Travel Time and Vehicle Operating Cost Benefit

The benefit from reduced travel time was calculated by determining the change in travel time for the future no-build and future build scenarios based on the existing annual average daily traffic and annual growth rates. The travel time reductions calculated in the build scenario assume a 5 mph increase to the existing 65 and 70 mph posted speed limits with the improvements to interstate standards. The 70 mph sections were justified to increase to 75mph based on [the ODOT study for increasing speed limits on rural interstates](#).

The time difference in vehicle hours traveled was then multiplied by the value of time provided in the BCA guidance (\$17.80 per hour for passenger vehicles and \$33.60 per hour for bus & truck drivers).

The Project will produce **travel time savings with a discounted benefit value of \$104.1 thousand (NPV)**.

**Table 2** below shows the improvement in travel time savings from the Project on an annual basis as a summary of the calculations and the cumulative benefit for the No-Build and Build Scenarios.



**Table 2: Travel Time Savings No-Build & Build Scenario with VHT Benefit Total**

Year	No-Build						Build				Reduction in VHT		VHT Benefit	VHT Benefit (NPV)
	Traffic Volumes		Vehicle Hours Traveled		Total Delay (Hours)		Traffic Volumes		Vehicle Hours Traveled		Passenger Vehicles	Trucks		
	Passenger Vehicles	Trucks	Passenger Vehicles	Trucks	Passenger Vehicles	Trucks	Passenger Vehicles	Trucks	Passenger Vehicles	Trucks				
2027	18,527	2,599	7,411	1,040	7,411	1,040	18,527	2,599	6,858	962	553	78	\$12,454	\$7,755
2028	18,816	2,639	7,526	1,056	7,526	1,056	18,816	2,639	6,965	977	562	79	\$12,647	\$7,361
2029	19,110	2,680	7,644	1,072	7,644	1,072	19,110	2,680	7,073	992	571	80	\$12,845	\$6,987
2030	19,408	2,722	7,763	1,089	7,763	1,089	19,408	2,722	7,184	1,008	579	81	\$13,045	\$6,632
2031	19,710	2,765	7,884	1,106	7,884	1,106	19,710	2,765	7,296	1,023	588	83	\$13,249	\$6,294
2032	20,017	2,808	8,007	1,123	8,007	1,123	20,017	2,808	7,409	1,039	598	84	\$13,455	\$5,974
2033	20,329	2,852	8,132	1,141	8,132	1,141	20,329	2,852	7,525	1,055	607	85	\$13,665	\$5,670
2034	20,647	2,896	8,259	1,158	8,259	1,158	20,647	2,896	7,642	1,072	616	86	\$13,878	\$5,382
2035	20,969	2,941	8,387	1,177	8,387	1,177	20,969	2,941	7,761	1,089	626	88	\$14,095	\$5,109
2036	21,296	2,987	8,518	1,195	8,518	1,195	21,296	2,987	7,883	1,106	636	89	\$14,315	\$4,849
2037	21,627	3,034	8,651	1,213	8,651	1,213	21,627	3,034	8,005	1,123	646	91	\$14,537	\$4,602
2038	21,965	3,081	8,786	1,232	8,786	1,232	21,965	3,081	8,130	1,140	656	92	\$14,764	\$4,368
2039	22,307	3,129	8,923	1,252	8,923	1,252	22,307	3,129	8,257	1,158	666	93	\$14,994	\$4,146
2040	22,655	3,178	9,062	1,271	9,062	1,271	22,655	3,178	8,386	1,176	676	95	\$15,228	\$3,935
2041	23,009	3,227	9,203	1,291	9,203	1,291	23,009	3,227	8,516	1,195	687	96	\$15,466	\$3,735
2042	23,367	3,278	9,347	1,311	9,347	1,311	23,367	3,278	8,649	1,213	698	98	\$15,707	\$3,545
2043	23,732	3,329	9,493	1,332	9,493	1,332	23,732	3,329	8,784	1,232	709	99	\$15,952	\$3,365
2044	24,102	3,381	9,641	1,352	9,641	1,352	24,102	3,381	8,921	1,251	720	101	\$16,201	\$3,194
2045	24,478	3,433	9,791	1,373	9,791	1,373	24,478	3,433	9,060	1,271	731	103	\$16,453	\$3,031
2046	24,859	3,487	9,944	1,395	9,944	1,395	24,859	3,487	9,201	1,291	742	104	\$16,710	\$2,877
2047	25,248	3,541	10,099	1,417	10,099	1,417	25,248	3,541	9,345	1,311	754	106	\$16,971	\$2,731
2048	25,640	3,597	10,256	1,439	10,256	1,439	25,640	3,597	9,491	1,331	766	107	\$17,235	\$2,592
Total												\$323,866	\$104,137	

Vehicle operating costs were calculated by determining the change in vehicle miles traveled along US-412. Due to the route limits staying almost identical between the no-build and build scenario, the operational benefit was negligible.

Safety Benefit

The Project produces **safety savings of \$138.6 million (NPV)**. The reduction in costs associated with crashes along US-412, using the existing crash rates provided by ODOT and crash modification factors (CMF), the corridor will experience less crashes due to safer interchange access. The future US-412 crashes were estimated utilizing a weighted average between Mayes and Rogers County, Oklahoma crash rates to determine the number of crashes on the new facility. The [Highway Safety Manual](#) resource of the [Crash Modification Factor \(CMF\) Clearinghouse](#) for converting at-grade intersections into a grade-separated interchange and raising the posted speed by 5 mph were utilized to identify the potential crash savings (CMF – 459, 42% crash reduction and CMF – 1252, 8% crash reduction).



These crash predictions were combined and subtracted from the projected no-build number of crashes to determine crash savings each year. The safety benefits by year are reflected below in **Table 3**.

**Table 3: Safety Crash Savings**

Safety Crash Savings				
Year	Total Cost		Potential Cost Savings	Potential Cost Savings (NPV)
	No Build	Build		
2027	\$32,683,700	\$17,440,022	\$15,243,678	\$9,492,997
2028	\$32,692,200	\$17,444,558	\$15,247,642	\$8,874,266
2029	\$32,856,400	\$17,532,175	\$15,324,225	\$8,335,363
2030	\$32,938,200	\$17,575,824	\$15,362,376	\$7,809,453
2031	\$32,951,300	\$17,582,814	\$15,368,486	\$7,301,457
2032	\$33,110,900	\$17,667,976	\$15,442,924	\$6,856,843
2033	\$44,719,400	\$23,862,272	\$20,857,128	\$8,654,967
2034	\$44,809,700	\$23,910,456	\$20,899,244	\$8,105,087
2035	\$45,524,100	\$24,291,660	\$21,232,440	\$7,695,613
2036	\$45,528,700	\$24,294,114	\$21,234,586	\$7,192,889
2037	\$45,619,000	\$24,342,298	\$21,276,702	\$6,735,659
2038	\$45,783,200	\$24,429,916	\$21,353,284	\$6,317,666
2039	\$45,791,700	\$24,434,451	\$21,357,249	\$5,905,457
2040	\$45,951,300	\$24,519,614	\$21,431,686	\$5,538,355
2041	\$46,041,600	\$24,567,798	\$21,473,802	\$5,186,204
2042	\$46,609,500	\$24,870,829	\$21,738,671	\$4,906,704
2043	\$46,846,300	\$24,997,186	\$21,849,114	\$4,609,003
2044	\$46,859,400	\$25,004,176	\$21,855,224	\$4,308,684
2045	\$47,023,600	\$25,091,793	\$21,931,807	\$4,040,917
2046	\$47,109,300	\$25,137,522	\$21,971,778	\$3,783,441
2047	\$47,273,500	\$25,225,140	\$22,048,360	\$3,548,251
2048	\$47,841,400	\$25,528,171	\$22,313,229	\$3,355,959
<b>Total</b>	<b>\$936,564,400</b>	<b>\$499,750,765</b>	<b>\$436,813,635</b>	<b>\$138,555,235</b>

The CMF methodology described above provided the most cost savings and best BCR for the project. As an alternative method of determining safety benefits, the statewide crash averages provided by ODOT for 2018-2020 were used to compare a divided four-lane partial access-controlled facility to a divided four-lane fully access-controlled facility. The reduction in fatal, injury, and overall crashes using this method was applied to the predicted future no-build crashes to determine an estimated number of build crashes. The difference of these crashes was multiplied by the same crash benefit dollar amounts to determine an overall crash benefit. This statewide crash average methodology resulted in a total benefit of \$134.8 million (NPV) and reduced the overall BCR to 1.67.

Environmental Cost Savings

The Project is not expected to positively affect the produced emissions along the corridor, resulting in **emissions damage savings of \$0 NPV over 20 years**. The methodology of testing for emission reduction was based on vehicle miles traveled (VMT). Since the limits of the corridor are not changing between build and no-build scenarios, there was no change in the VMT calculated. The overall impact to emissions is considered negligible at this time, however the travel time savings and significant improvements to safety will have a positive and lasting impact to the corridor for years to come.

Operations & Maintenance Costs Reduction

The Program is projected to increase operations & maintenance costs by \$463.4 thousand dollars (NPV) over the 20-year period analyzed. The corridor will receive the long-lasting improvements it needs to continue to support estimated growth and safe travel for local users. The total Operations & Maintenance costs for this Project are outlined below in **Table 4**.



**Table 4: Operation & Maintenance Reduced Cost Benefit**

20 Year O&M Costs				
Year	Existing O&M	Future O&M	Savings	Savings (NPV)
2029	\$0	\$150,000	(\$150,000)	(\$81,590)
2030	\$0	\$85,000	(\$85,000)	(\$43,210)
2031	\$0	\$0	\$0	\$0
2032	\$0	\$85,000	(\$85,000)	(\$37,741)
2033	\$15,000	\$135,000	(\$120,000)	(\$49,796)
2034	\$0	\$85,000	(\$85,000)	(\$32,964)
2035	\$0	\$0	\$0	\$0
2036	\$0	\$85,000	(\$85,000)	(\$28,792)
2037	\$0	\$0	\$0	\$0
2038	\$15,000	\$220,000	(\$205,000)	(\$60,652)
2039	\$0	\$0	\$0	\$0
2040	\$0	\$85,000	(\$85,000)	(\$21,966)
2041	\$0	\$0	\$0	\$0
2042	\$0	\$85,000	(\$85,000)	(\$19,186)
2043	\$15,000	\$135,000	(\$120,000)	(\$25,314)
2044	\$0	\$85,000	(\$85,000)	(\$16,757)
2045	\$0	\$0	\$0	\$0
2046	\$0	\$85,000	(\$85,000)	(\$14,637)
2047	\$0	\$0	\$0	\$0
2048	\$15,000	\$220,000	(\$205,000)	(\$30,832)
<b>Total</b>	<b>\$60,000</b>	<b>\$1,540,000</b>	<b>(\$1,480,000)</b>	<b>(\$463,437)</b>



Project Costs

The project has a **total capital cost of \$139,790,000** in 2020 dollars over a seven-year construction period from 2022 to December 2028. Numbers shown are in 2020 dollars to provide a uniform base year. All costs by year are shown in **Table 5** which includes its Net Present Value (NPV) based on a discount rate of 7 percent.

At the end of the 20-year analysis period, the corridor will have a **discounted residual value of \$80.6 million** as calculated using the FHWA-recommended residual value calculation for the time before US-412 will need to be replaced (50 years).

Benefits Summary

The US-412 Improvements for Interstate Designation Project has a **Benefit-Cost Ratio of 1.71**. This ratio was derived by dividing total discounted benefits by total discounted costs over a 20-year period. It and other figures shown below in **Table 6** and throughout this methodology memo were derived based on [FHWA 2022 BCA Guidance](#).

**Table 5: Summary of Estimated Capital Costs**

Project Costs			
Year	Percent Project Cost Paid	Project Cost	Project Cost (NPV)
2020		\$0	\$0
2021		\$0	\$0
2022	1%	\$1,445,187	\$1,262,282
2023	7%	\$9,556,151	\$7,800,666
2024	4%	\$5,851,849	\$4,464,348
2025	24%	\$33,624,287	\$23,973,652
2026	21%	\$29,770,842	\$19,837,569
2027	21%	\$29,770,842	\$18,539,784
2028	21%	\$29,770,842	\$17,326,901
2029		\$0	\$0
2030		\$0	\$0
2031		\$0	\$0
2032		\$0	\$0
2033		\$0	\$0
2034		\$0	\$0
2035		\$0	\$0
2036		\$0	\$0
2037		\$0	\$0
2038		\$0	\$0
2039		\$0	\$0
2040		\$0	\$0
2041		\$0	\$0
2042		\$0	\$0
2043		\$0	\$0
2044		\$0	\$0
2045		\$0	\$0
2046		\$0	\$0
2047		\$0	\$0
2048		(\$83,874,000)	(\$12,614,835)
<b>Total</b>	<b>100%</b>	<b>\$55,916,000</b>	<b>\$80,590,367</b>

**Table 6: Summary**

Project	Capital Costs	Project Costs (NPV)	Total Net Benefit	Total Net Benefit (NPV)	Benefit-Cost Ratio
2022 BCA SUMMARY - U.S. 412 IMPROVEMENTS TO INTERSTATE STANDARDS PROJECT	\$139,790,000	\$80,590,367	\$435,657,501	\$138,195,935	1.71