I-44 and US-75 Corridor Improvement Projects, Tulsa, Oklahoma
Appendix Report: Project Benefit Cost Analysis
16 March 2021

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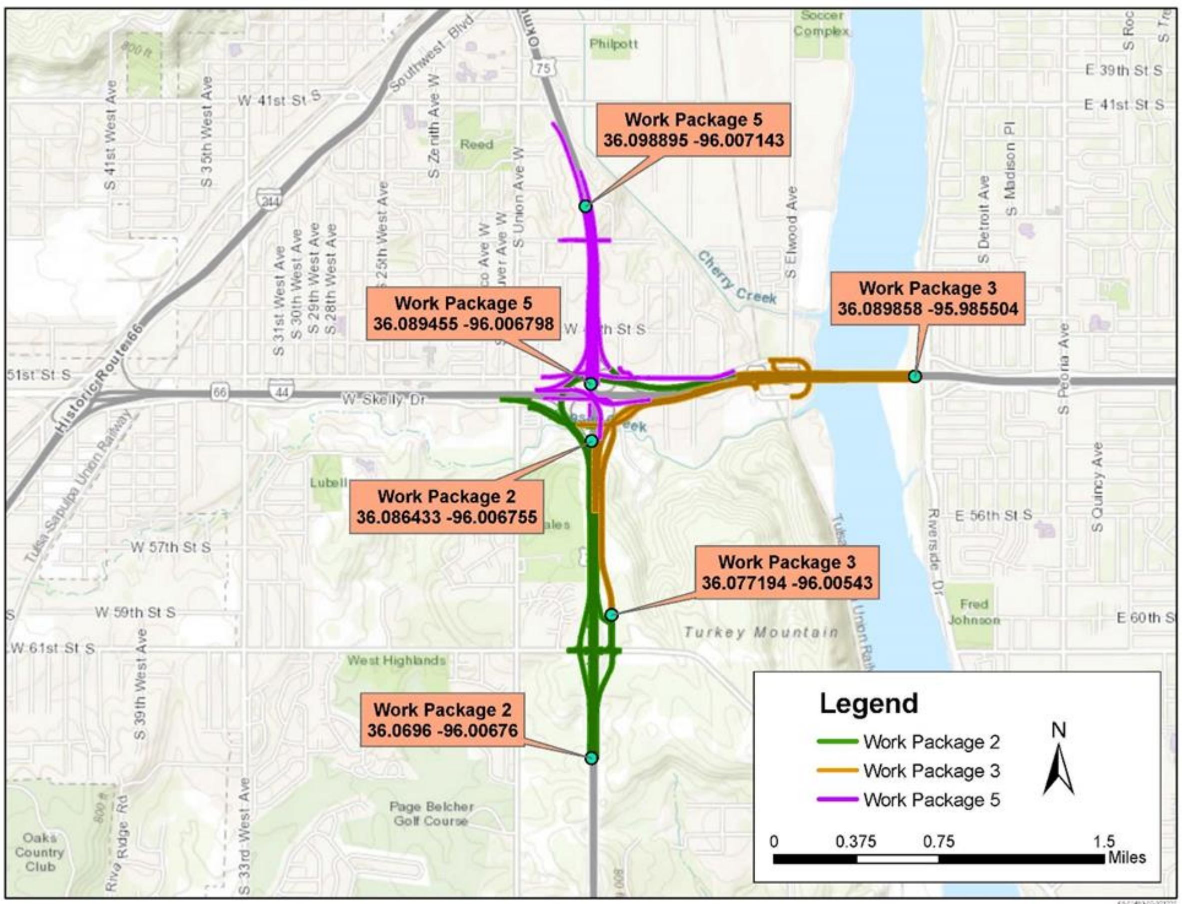

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Table of Contents

1 Overview of Approach

A Benefit Cost Analysis (BCA) was conducted for WP 2, 3, and 5 of the I-44/US-75 Interchange, a major part of the overall I-44 and US-75 Corridor Improvement Projects in Tulsa County, Oklahoma. The BCA follows the most recent 2021 USDOT guidance for BCAs, which provides both methodological guidance and specific values for monetizing various types of benefits, such as hourly values of travel time, the economic cost of vehicle crashes (including pedestrian-vehicle incidents), and air emissions. All values from that guidance are in 2019 dollars. All monetary values in the BCA, including costs, are expressed in constant 2019 dollars.

The following general parameters and assumptions have been used in carrying out the BCA:

- A real discount rate of 7 percent is applied to all costs and benefits except for carbon emissions reductions, which are discounted at 3 percent.
- A project life cycle of 25 years is assumed, which represents a mid-point between a recommended 20-year horizon of analysis for rehab and replace projects, vs. 30 years for new right-of-way and facilities. The I-44 and US-75 Corridor Improvement Projects comprises multiple individual elements reflecting a mix of old and rehabbed infrastructure.
- No residual value is assumed at the close of the 25 years of operation.
- The project construction is assumed to commence in 2024 and end in late 2026, with operation commencing in 2027. Some advance right-of-way acquisition for interchange construction will occur in the years 2021 – 2024.
- All costs and benefits are in 2019 dollars.
- The year 2019 was used as the base year for discounting; that is, 2019 is considered year zero for discounting.

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2 Project Costs

Major capital, maintenance, and bridge rehab and repair costs are summarized in **Table 1**. These exclude routine maintenance for items such as patching, snow or ice clearance, or other non-capital items.

Table 1: Build and No-Build Capital and Major Rehab Cost Summary by Year

YEAR	NO-BUILD				BUILD		
	Maint. & Rehab Costs for I-44/ US 75	Bridge Rehab Costs	Bridge Damage repair	TOTAL	Capital Costs	Maintena nce	TOTAL
2016	4,900	-	-	4,900	-		-
2017	-	2,500	-	2,500	-		-
2018	1,700	-	-	1,700	-		-
2019	-	-	-	-	-		-
2020	-	-	-	-	-		-
2021	-	2,400	-	2,400	-		-
2022	-	-	-	-	-		-
2023	-	-	-	-	-		-
2024	-	-	-	-	68,600		68,600
2025	-	-	-		68,600		68,600
2026	-	-	-	-	68,600	1,000	69,600
2030	6,600	2,000	100	8,700	-	-	-
2035	-	3,300	100	3,400	-	-	-
2040	6,600	4,900	100	11,600	-	-	-
2045	-	-	100	100	-	5,000	5,000
2050	6,600	10,000	100	16,700	-	2,500	2,500
2055	-	-	-	-	-	-	-
2060	-	-	-	-	-	-	-
TOTAL	**$26,400**	**$25,100**	**$600**	**$52,000**	**$205,800**	**$8,500**	**$214,300**

Source: Oklahoma DOT design engineers

2.1 Capital Cost

The estimated capital cost of combined WP 2, 3, and 5 is $205.8 million in 2019 dollars (including contingency), and is broken down as follows:

- WP 2: $75.1 million
- WP 3: $60.2 million
- WP 5: $70.5 million

2.2 Operations and Maintenance Costs

The I-44 and US-75 Corridor Improvement Projects will result in very little difference in lane mileage compared to the No-Build and as such, no incremental difference in routine lane-related maintenance costs has been assumed. However, as seen in the cost summary, there are significant differences in non-routine maintenance, bridge repair, and rehabilitation costs, and bridge damage costs. Under the No-Build, ODOT engineers estimate $52 million has been and will be spent for non-routine roadway and bridge maintenance, compared with $8.5 million for the Build (i.e., with I-44 and US-75 Corridor Improvement Projects). Except for $9.1 million already spent before today for the existing infrastructure, US-75, these represent significant future life cycle cost savings, which are included as cost offsets for BCA purposes.

3 Project Benefits

3.1 Monetized Benefits Included in the BCA

Four primary categories of benefit have been captured by the BCA: reduced motor vehicle crashes, travel delay savings, logistics (freight) cost savings, and emissions cost reductions. As noted above, life cycle and cost savings were moved to the denominator of the benefit cost ratio calculation, following USDOT BCA guidance. Furthermore, economic benefits such as enhanced productivity (over and above those embodied in travel time savings) are not included. However, the overall improvements in regional accessibility may generate additional productivity benefits, such as agglomeration benefits reflecting the improved ability of employers to access specialized labor.

Crash Reductions: Because much of the I-44 and US-75 Corridor Improvement Projects involve reconfiguring the complex network of US-75 and I-44 interchanges and approach lanes and roadways to the interchanges, a significant share of the benefits anticipated will be reduced vehicular collisions and improved pedestrian safety. To estimate these likely impacts, a detailed data list of all collisions that occurred throughout the I-44 and US-75 Corridor Improvement Projects limits between the years 2014 and 2018 were collected, by severity. Levels of severity were measured across a scale of one to five, including fatal crashes, injury crashes of three degrees of severity, and property-damage-only crashes. These levels of severity are assumed to be roughly equivalent to KABCO scale measurements.

During the five-year period (covering full calendar years 2014 through 2018), the following count of crashes was obtained from ODOT:

- 408 PDO (property damage only)
- 201 Injury Severity 2 (least severe)
- 134 Injury Severity 3
- 25 Injury Severity 4
- 5 Fatal (including 1 pedestrian fatality

Table 2 summarizes the accident data, VMT data, and calculations leading to estimated accident reductions.

Table 2. Crash rate reduction calculations

Crash Reductions for Work Packages 2, 3, and 5							
Annual Crashes (2014-2018)	Total	Annual Average	Crashes/MVMT				
PDO	408	81.6	1.10				
Injury Severity 2	201	40.2	0.54				
Injury Severity 3	134	26.8	0.36				
Injury Severity 4	25	5.0	0.07				
Fatal	5	1.0	0.01				
VMT	2016 Actual	2040 Projected					
WP2	29,739,324	42,872,225					
WP3	28,454,999	38,123,064					
WP5	15,673,173	21,149,031					
Total	73,867,496	102,144,319					
Assumed Crash Reduction Factor							
45%							
Projected Annual Crashes (No Build)	2016	2025	2030	2035	2040	2045	2050
PDO	81.60	92.15	98.59	105.48	112.85	120.73	129.17
Injury Severity 2	40.20	45.40	48.57	51.96	55.59	59.48	63.63
Injury Severity 3	26.80	30.26	32.38	34.64	37.06	39.65	42.42
Injury Severity 4	5.00	5.65	6.04	6.46	6.91	7.40	7.91
Fatal	1.00	1.13	1.21	1.29	1.38	1.48	1.58
Projected Annual Crash Reduction (Build)	2016	2025	2030	2035	2040	2045	2050
PDO	n/a	41.47	44.36	47.46	50.78	54.33	58.13
Injury Severity 2	n/a	20.43	21.86	23.38	25.02	26.77	28.64
Injury Severity 3	n/a	13.62	14.57	15.59	16.68	17.84	19.09
Injury Severity 4	n/a	2.54	2.72	2.91	3.11	3.33	3.56
Fatal	n/a	0.51	0.54	0.58	0.62	0.67	0.71

Sources of input data: Oklahoma DOT
Calculations: EBP

Based on these data, combined with annual vehicle miles traveled (VMT) measured across the project, crash rates were calculated (crashes per million VMT) and applied to ODOT's estimates of project-wide VMT in the future, and a baseline of total anticipated crashes without the I-44 and US-75 Corridor Improvement Projects was calculated for the entire project horizon of 25 years, through the year 2050. Next, the FHWA's Crash Modification Factor (CMF) database was consulted to obtain the most applicable Crash Reduction Factor (CRF). This search yielded a most relevant CMF of 55 percent (and thus a CRF of 45 percent). The selected CMF/CRF is obtained from research involving the safety effects of replacing cloverleaf interchanges with directional lanes. The relevant CMF was then applied to the future stream of No-Build crashes (by category of severity) to obtain estimates of reduced annual crashes over the study period.

The I-44 and US-75 Corridor Improvement Projects will generate significant savings in the human costs of crashes. Over the 25 years, it is estimated that about 15 lives will be saved, and another 77 serious injury-crashes will be avoided.

Travel Delay Savings: ODOT has provided an analysis of travel delay reductions based on the application of the VISSIM traffic simulation model to a future 2045 build year. The model simulated the effects of the I-44 and US-75 Corridor Improvement Projects (WP 2, 3, and 5). Based on estimates provided by ODOT, the BCA analysis assumes that 75 percent of the total travel delay reductions due to the entire I-44 and US-75 corridor improvements can be attributed to WPs 2, 3 and 5. Travel delay savings for years before 2045 were reduced based on the anticipated compound annual growth rates (CAGR) in VMT projected for the corridor of about 1.36 percent per year. For the years after 2045, delay was correspondingly increased by the same CAGR. In 2030, approximately 933 hours of travel delay would be saved by the I-44 and US-75 Corridor Improvement Projects each workday, covering morning and evening peak periods combined. Travel delay savings increases to approximately 1,075 hours of delay per workday in 2045.

Table 3 presents the outputs of the VISSIM run. **Error! Reference source not found.** presents the computations to derive the annual travel delay for trucks (vehicle hours of delay) and passenger (passenger hours of delay). These savings were monetized utilizing the values of time prescribed in the USDOT BCA guidance.

Table 3. VISSIM travel delay outputs, Build and No-Build

AM Period	DelayTot (Seconds)			
	All	Auto	Single Axle Truck	Multi-Axle Truck
2045 AM - No Action	4,048,058.1	3,672,981.5	136,664.3	238,412.3
Ult Build AM 2045	2,458,430.5	2,295,219.8	75,520.5	87,690.2
PM Period	DelayTot (Seconds)			
	All	Auto	Single Axle Truck	Multi-Axle Truck
2045 PM - No Action	5,247,407.8	4,756,955.2	189,138.2	301,314.3
Ult Build PM 2045	1,108,530.7	999,481.1	43,956.0	65,093.6

Source: Garver Engineering and ODOT

Table 4. Travel delay calculations

Daily Vehicle Hours	2025	2030	2035	2040	2045	2050
Auto	814	871	933	999	1,070	1,145
Single Axle Truck	33	35	37	40	43	46
Multi-Axle Truck	61	66	70	75	81	86
Annual Vehicle Hours	2025	2030	2035	2040	2045	2050
Auto	203,386	217,799	233,233	249,761	267,460	286,149
Single Axle Truck	8,172	8,751	9,371	10,035	10,746	11,497
Multi-Axle Truck	15,325	16,411	17,574	18,820	20,153	21,561
Annual passenger hours saved	301,011	322,342	345,185	369,646	395,841	423,500
NOTES						
DelayTot - Total delay of all vehicles that are in the network or have already left it.						
Delay savings attributable to Work Packages 2,3, and 5 equal 75% of total project-wide VISSIM results						
Delay savings for years other than 2045 based on CAGR for project VMT. Delay savings reduced for years prior to 2045 by compound growth factor of (1 - CAGR)						

Source: EBP

Air Emissions Reductions: To support the air emissions reduction analysis, INCOG ran the Environmental Protection Agency's Motor Vehicle Emission Simulator (MOVES3) model for years 2030 and 2045. Based on model runs, air emissions rates were derived per hour of travel delay for carbon dioxide (CO2), nitrous oxide, sulfur oxide, and particulate matter 2.5. Based on air emission rates, combined with the travel delay reductions, annual emissions reductions were calculated, and monetized. The I-44 and US-75 Corridor Improvement Projects will reduce over 8.6 tons of CO2 through reduced congestion in 2045. (see **Table 6**).

Table 5. Air emissions rates per hour of travel delay.

MOVES Output	Grams/hour of travel delay (2019)	Grams/hour of travel delay (2030)	Grams/hour of travel delay (2045)
CO_2	11275.447	8830.455	7708.848
NOx	8.994	1.545	0.252
PM2.5	0.129	0.055	0.034
SO2	0.119	0.057	0.050

Source: INCOG Analysis, from EPA

Table 6. Calculation of emissions benefits for selected years

Emissions Savings Per Hour of Delay	2019	2030	2035	2040	2045	2050
CO_2 Savings	0.0113	0.0088	0.0085	0.0081	0.0077	0.0073
NOx Savings	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PM Savings	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SOx Savings	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Emissions Benefit Per Hour of Delay	2019	2030	2035	2040	2045	2050
CO_2 Benefit	-	0.5387	0.5666	0.5820	0.6013	0.6161
Nox Benefit	-	0.0273	0.0200	0.0123	0.0045	0.0000
PM Benefit	-	0.0472	0.0410	0.0348	0.0286	0.0224
SOx Benefit	-	0.0028	0.0026	0.0025	0.0024	0.0023
Emissions Benefit (Undiscounted $2019)	2019	2030	2035	2040	2045	2050
CO_2 Benefit	-	$130,873	$147,415	$162,142	$179,401	$196,676
Nox Benefit	-	$6,642	$5,216	$3,426	$1,355	$0
PM Benefit	-	$11,462	$10,662	$9,690	$8,528	$7,145
SOx Benefit		$669	$686	$701	$715	$726
Total (Non-CO2)	-	$18,774	$16,564	$13,817	$10,597	$7,871

Source: EBP

Shipper/Logistics Cost Savings: Shipper/logistics cost savings are based on Freight Analysis Framework (FAF) Tulsa FAF region for 2020, truck travel delay savings, and data from the TREDIS-based Multimodal Benefit Cost Analysis (MBCA) tool. The FAF data were used to develop a commodity mix breakdown of the trucking data (see **Table 7**), and the commodity mixes were cross referenced to Standard Classification of Transportation Goods (SCTG) data. These values are then applied to the truck travel delay savings to derive ton hours saved by commodity type and SCTG category. Ton hours saved are then multiplied by the hourly value of shipper delay for each commodity (hourly values are obtained from the TREDIS-based MBCA model). Costs are summed across all commodity types to derive the annual savings. l (see **Table 8**).

Table 7. Freight vehicle commodity mix breakout (Tulsa)

SCTG2	SCTG Description	Truck-Commodity Mix
1	Live animals/fish	0.3%
2	Cereal grains	2.7%
3	Other ag prods.	0.5%
4	Animal feed	0.6%
5	Meat/seafood	0.3%
6	Milled grain prods.	0.8%
7	Other foodstuffs	3.0%
8	Alcoholic beverages	0.3%
9	Tobacco prods.	0.0%
10	Building stone	0.0%
11	Natural sands	0.3%
12	Gravel	0.4%
13	Nonmetallic minerals	1.1%
14	Metallic ores	0.6%
15	Coal	0.0%
16	Crude petroleum	0.0%
17	Gasoline	2.2%
18	Fuel oils	1.4%
19	Coal-n.e.c.	50.0%
20	Basic chemicals	1.2%
21	Pharmaceuticals	0.0%
22	Fertilizers	7.8%
23	Chemical prods.	0.5%
24	Plastics/rubber	1.0%
25	Logs	0.0%
26	Wood prods.	1.4%
27	Newsprint/paper	0.3%
28	Paper articles	1.7%
29	Printed prods.	0.3%
30	Textiles/leather	0.2%
31	Nonmetal min. prods.	6.4%
32	Baseline metals	5.3%
33	Articles-Baseline metal	2.5%
34	Machinery	1.7%
35	Electronics	0.9%
36	Motorized vehicles	0.8%
37	Transport equip.	0.1%
38	Precision instruments	0.0%
39	Furniture	0.4%
40	Misc. mfg. prods.	0.8%
41	Waste/scrap	0.3%
43	Mixed freight	1.8%
99	Unknown	0.0%

Source: Tulsa FAF Region (2020)

Table 8. Calculation of shipper benefits for selected years

SCTG2	SCTG Description	2025	2030	2035	2040	2045	2050
1	Live animals/fish	$2,872	$3,076	$3,294	$3,527	$3,777	$4,041
2	Cereal grains	$9,124	$9,771	$10,463	$11,205	$11,999	$12,837
3	Other ag prods.	$2,460	$2,634	$2,821	$3,021	$3,235	$3,461
4	Animal feed	$2,816	$3,016	$3,230	$3,459	$3,704	$3,962
5	Meat/seafood	$3,185	$3,411	$3,652	$3,911	$4,188	$4,481
6	Milled grain prods.	$4,515	$4,835	$5,177	$5,544	$5,937	$6,352
7	Other foodstuffs	$19,750	$21,150	$22,649	$24,254	$25,972	$27,787
8	Alcoholic beverages	$2,531	$2,710	$2,902	$3,108	$3,328	$3,560
9	Tobacco prods.	$26	$28	$30	$33	$35	$37
10	Building stone	$59	$63	$67	$72	$77	$83
11	Natural sands	$294	$314	$337	$361	$386	$413
12	Gravel	$383	$410	$439	$470	$503	$538
13	Nonmetallic minerals	$2,864	$3,067	$3,284	$3,517	$3,766	$4,029
14	Metallic ores	$749	$802	$859	$920	$985	$1,054
15	Coal	$20	$21	$23	$24	$26	$28
16	Crude petroleum	$154	$165	$177	$190	$203	$217
17	Gasoline	$9,900	$10,602	$11,353	$12,157	$13,019	$13,929
18	Fuel oils	$5,253	$5,626	$6,024	$6,451	$6,909	$7,391
19	Coal-n.e.c.	$203,688	$218,122	$233,580	$250,132	$267,858	$286,574
20	Basic chemicals	$6,839	$7,324	$7,843	$8,399	$8,994	$9,622
21	Pharmaceuticals	$830	$889	$952	$1,020	$1,092	$1,168
22	Fertilizers	$24,352	$26,078	$27,926	$29,905	$32,024	$34,262
23	Chemical prods.	$5,509	$5,899	$6,317	$6,765	$7,244	$7,750
24	Plastics/rubber	$10,513	$11,258	$12,056	$12,910	$13,825	$14,791
25	Logs	$136	$146	$156	$167	$179	$191
26	Wood prods.	$8,644	$9,257	$9,913	$10,616	$11,368	$12,162
27	Newsprint/paper	$2,665	$2,853	$3,056	$3,272	$3,504	$3,749
28	Paper articles	$14,326	$15,342	$16,429	$17,593	$18,840	$20,156
29	Printed prods.	$2,206	$2,362	$2,530	$2,709	$2,901	$3,103
30	Textiles/leather	$2,082	$2,230	$2,388	$2,557	$2,738	$2,929
31	Nonmetal min. prods.	$26,973	$28,885	$30,931	$33,123	$35,471	$37,949
32	Baseline metals	$35,827	$38,366	$41,085	$43,996	$47,114	$50,406
33	Articles-Baseline metal	$21,485	$23,008	$24,638	$26,384	$28,254	$30,228
34	Machinery	$43,805	$46,909	$50,233	$53,793	$57,605	$61,630
35	Electronics	$23,403	$25,062	$26,838	$28,740	$30,776	$32,927
36	Motorized vehicles	$20,882	$22,362	$23,947	$25,644	$27,461	$29,380
37	Transport equip.	$1,337	$1,432	$1,533	$1,642	$1,758	$1,881
38	Precision instruments	$1,356	$1,452	$1,555	$1,665	$1,783	$1,907
39	Furniture	$4,629	$4,957	$5,308	$5,684	$6,087	$6,512
40	Misc. mfg. prods.	$13,750	$14,724	$15,768	$16,885	$18,082	$19,345
41	Waste/scrap	$2,083	$2,231	$2,389	$2,558	$2,740	$2,931
43	Mixed freight	$11,414	$12,223	$13,089	$14,017	$15,010	$16,059
99	Unknown	$0	$0	$0	$0	$0	$0
	Total	$555,691	$595,070	$637,240	$682,398	$730,756	$781,817

Source: EBP

3.2 Project Benefits Not Included in the BCA

Due to time and data limitations, the analysis does not include all secondary benefits of reduced congestion, over and above the estimated reduction in travel delay itself. Severe bottlenecks and driving under highly congested conditions, which characterize several of the ramp and ramp approach roadways of the interchange, generally introduce significant unreliability into travel decision making, often necessitating that drivers build in added buffer time to their trips.

No significant changes in VMT are anticipated as a result of the I-44 and US-75 Corridor Improvement Projects; accordingly, there are no changes in vehicle operating and maintenance costs and emissions measured for BCA purposes. Since some significant bottlenecks will be alleviated, and average speeds through the system will increase during AM and PM peak periods.

4 BCA Results

Based on the assumptions, methodology, and other information presented above, the project yields a Benefit-Cost Ratio of 1.21 and a Net Present Value of $27.1 million. The results are summarized in **Table 9.** About 35 percent of the total monetized benefits are travel delay savings. Crash reductions comprise 60 percent, 3 percent are shipper cost savings, and 1.5 percent are emissions benefits.

Table 9. BCA Results

Benefit-Cost	Amount
Discounted Initial Capital Costs	$137.3
Discounted Life Cycle Cost Savings	-$10.5
Facilities Residual Value	$0.0
Total Discounted Costs	**$126.9**
Crash Reductions Benefits	$92.2
Travel Delay Cost Savings	$54.4
Emissions Reduction Benefits	$2.4
Shipper/Supply Chain Cost Savings	$4.9
Total Discounted Benefits	**$154.0**
Benefit Cost Ratio	**1.21**
Net Present Value ($M)	**$27.1**

Source: EBP

Freight rating: The INFRA grant guidance, as documented in recent INFRA grant BCA webinars, considers a new metric, the project Freight Rating. This is the ratio of benefits attributable to freight as a share of total benefits. Two categories of freight benefits were measured: shipper/supply chain cost savings and truck travel time reductions. The present value of those two categories of freight categories equal 11.2 percent of total project benefits. The present value of truck delay savings equals $12.2 million, while the present value of logistics cost savings sums to $4.9 million over the 25-year time horizon.