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35th Avenue Innovation Corridor Project

Benefit-Cost Analysis Appendix

BUILD 2019

Prepared for City of Phoenix by AECOM

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Exhibits

1. Executive Summary

A benefit-cost analysis (BCA) was conducted to support the grant application of the City of Phoenix for the U.S. Department of Transportation's (USDOT) BUILD grant program. This analysis was conducted in accordance with the December 2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs. Capital outlays are scheduled to begin in 2020, and construction is scheduled to be completed in 2024. All values are in 2017 dollars discounted to 2019 at a 7 percent rate and cover a 20-year analysis period beginning with operations in Fall 2024.

Exhibit 1 presents the Impact Matrix, which describes the No Build Alternative (baseline), the Project as a whole, and the estimated results.

Exhibit 1: Impact Matrix

Current Status/Baseline & Problem to be Addressed	Change to Baseline or Alternatives	Types of Impacts	Affected Population	Economic Benefit (Net Present Values, $2017 M, Discounted by 7%)	Page Reference in BCA
A 3.2-mile area on 35th Avenue between Interstate 10 (I-10) and Camelback Road that has a higher than average crash rate.	The project would implement a series of improvements in the corridor to enhance safety and provide additional benefits. Improvements include signalized crossings, center medians, street lighting, fiber optic cables, rebuild of intersections, signal timing, and pavement maintenance.	Safety			
		Reduced Roadway Fatalities and Crashes	Drivers, passengers, pedestrians and bicyclists	$24.83 M	11
		Environmental Sustainability			
		Emission Savings	City of Phoenix residents	$0.04 M	13
		Economic Competitiveness			
		Travel Time Savings	Drivers and passengers	$14.03 M	12
		State of Good Repair			
		Residual Savings	City of Phoenix Taxpayers	$1.14 M	14

Source: AECOM

Exhibit 2 summarizes long-term outcomes of the Project. Taken in total, the Project provides $39.4 million in benefits over the analysis period, using a 7 percent discount rate. The benefits include reduced roadway fatalities and crashes, travel time savings, emission savings, and residual savings. Compared to a similarly discounted capital cost estimate, the Benefit-Cost Ratio for the Project is 2.12, a good return on this critical investment for the region. The net benefits of the Project are $20.8 million using a 7 percent discount rate.

Exhibit 2: Costs and Key Benefits Delivered by Long-Term Outcomes (2024 – 2044)

	7% Discount Rate
Costs (2017 $M)	
Capital Cost	$18.58
Total Costs	*$18.58*
Benefits (2017 $M)	
Safety Benefits	
Reduced Roadway Fatalities and Crashes	$24.83
Environmental Sustainability Benefits	
Emission Savings	$0.04
Economic Competitiveness Benefits	
Travel Time Savings	$14.03
State of Good Repair Benefits	
Residual Savings	$1.14
Net Operating & Maintenance Costs	-$0.63
Total Benefits	*$39.41*
Outcome	
Net Benefits (2017 $M)	$20.83
Benefit-Cost Ratio	**2.12**

Source: AECOM analysis

2. Introduction

The 35th Avenue Innovation Corridor is a comprehensive infrastructure improvement project for a 3.2-mile area on 35th Avenue in Phoenix, Arizona between Interstate 10 (I-10) and Camelback Road. The project will transform the study area into a safe and efficient route for commuters and a high volume of students from the 11 schools within the study area (see Exhibit 3). The project would implement a series of improvements that target current pedestrian and vehicular safety concerns by incorporating traffic management strategies with safety countermeasures to ultimately create a safe, attractive, and efficient corridor for all modes of transportation.

Proposed Improvements include:

- **Signalized Mid-Block Crossings:** A pedestrian hybrid beacon, also referred to as a HAWK, is a mid-block pedestrian crossing that temporarily stops traffic when a pedestrian requests a crossing. With strategic placement at high-crossing locations, this improvement would be extremely effective in reducing pedestrian crossing-related conflicts and improving pedestrian access to destinations within the study area.
- **Center Medians**: Small center medians will provide refuge areas for pedestrians while having minimal impacts to vehicular movement. The strategically-placed medians will target pedestrian safety concerns without restricting access to businesses.
- **Street Lighting**: Installing additional LED street lighting along the west side of the corridor alignment will improve visibility and reduce conflicts between vehicles, pedestrians, and other hazards during dark lighting conditions.
- **Fiber Optic Cables:** Fiber optic infrastructure will allow the city to implement signal timing and progression speed display and will increase preparedness for future technologies and corridor traffic improvements.
- **Full Intersection Rebuild:** The project will upgrade all traffic signals to enable future technology applications throughout the study area. As part of the traffic signal upgrades, the city will implement a flashing yellow left-turn arrow to improve safety at intersections. Additionally, the project will upgrade ADA ramps and pedestrian activated crossing push-buttons at all signalized intersections.
- **Signal Timing/ Progression Speed:** The project will optimize signal timing within the study area and implement a dynamic display of the recommended progression speed for vehicles to make sequential green lights. This improvement will smooth traffic flow and reduce travel time delays within the study area.
- **Pavement Maintenance:** The project will complete a mill and overlay treatment between Indian School Road and Camelback Road. The treatment will improve the pavement condition of the road from “poor” to “good”.

Exhibit 3: Project Area, Safety Concerns

Source: AECOM

3. Benefit Analysis Framework

The benefits analysis was conducted using the Benefit-Cost Analysis Guidance for Discretionary Grant Programs document as a guide for preferred methods and monetized values.[1] The parameters of the benefits analysis follow the protocols set by the Office of Management and Budget (OMB) Circular A-94 as well as the recommended benefit quantification methods by the USDOT. Generally, standard factors and values accepted by federal agencies were used for the benefits calculation except in cases where Project-specific values or prices were available. In all such cases, modifications are noted and references are provided for data sources. The analysis follows a conservative estimation of the benefits. By adhering to a strict standard of what could be included in the benefits analysis, actual total benefits may be greater than depicted in the results.

The No Build Alternative assumes that if the Project is not built, safety concerns along the corridor would continue to deteriorate, existing traffic signals will be unable to accommodate advanced/evolving Intelligent Transportation Systems (ITS) applications, pavement condition would continue to deteriorate, and congestion along the corridor would become worse. Under the No Build Alternative, the purpose of and need for the Project would not be met. The Project was compared to the No Build Alternative to identify benefits and costs.

[1] https://www.transportation.gov/sites/dot.gov/files/docs/mission/office-policy/transportation-policy/14091/benefit-cost-analysis-guidance-2018.pdf

A custom model was developed to estimate the future benefits for the Project. Benefits were estimated over a 20-year period of analysis beginning at the end of the construction period. The 20-year period of analysis runs from 2024 through 2044. The base year is 2019 and all values were discounted to the base year.

The benefits are expressed in constant 2017 dollars, which avoids forecasting future inflation and escalating future values for benefits and costs accordingly. The gross domestic product chained price index from the OMB was used to adjust past cost estimates or price values into 2017 dollar terms (OMB, 2018).

The use of constant dollar values requires the use of a real discount rate for discounting to the present value. Projects expecting to use federal funding are required to use a 7 percent discount rate.

4. Analysis Assumptions

The BCA is based on several assumptions on the differences between the No Build Alternative and the Build Alternative (implementation of the Project improvements). A list of assumptions for the Project is provided in the BCA workbook (see Inputs tab in the file Phoenix_35Avenue_BUILD2019_BCA.xlsx) as well as in Exhibit 4.

Exhibit 4: BCA Calculation Inputs

Input	Value	Source
General		
Discount Rate	7%	December 2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs
Deflator for converting $ values to 2017$	See "Deflator" Sheet	https://www.whitehouse.gov/wp-content/uploads/2019/03/hist10z1-fy2020.xlsx
Base year dollar	2017	
Discount year	2019	
Annualization factor	260	Assumed to reflect weekday peak periods in a year
Vehicle occupancy	1.32	Average Auto Occupancy - 2019; MAG
Economic Competitiveness		
Value of Time - Personal (2017$)	$14.80	December 2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs
Environmental Sustainability		
VOC Value of Emissions (2017$) per short ton	$2,000	December 2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs

Input	Value	Source
NOx Value of Emissions (2017$) per short ton	$8,300	December 2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs
PM Value of Emissions (2017$) per short ton	$377,800	December 2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs
SOx Value of Emissions (2017$) per short ton	$48,900	December 2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs
CO2 Value of Emissions (2017$) per short ton	Varies	
VOC Emission Rates Per Hour (Weighted Average), g/hr	3.0997	Source: "Idling Vehicle Emissions for Passenger Cars, Light-Duty Trucks, and Heavy-Duty Trucks Emission Facts", EPA420-F-08-205, October 2008
THC Emission Rates Per Hour (Weighted Average), g/hr	3.6037	Source: "Idling Vehicle Emissions for Passenger Cars, Light-Duty Trucks, and Heavy-Duty Trucks Emission Facts", EPA420-F-08-205, October 2008
CO Emission Rates Per Hour (Weighted Average), g/hr	58.8671	Source: "Idling Vehicle Emissions for Passenger Cars, Light-Duty Trucks, and Heavy-Duty Trucks Emission Facts", EPA420-F-08-205, October 2008
Nox Emission Rates Per Hour (Weighted Average), g/hr	3.6715	Source: "Idling Vehicle Emissions for Passenger Cars, Light-Duty Trucks, and Heavy-Duty Trucks Emission Facts", EPA420-F-08-205, October 2008
CO2 Emission Rates Per Hour, g/hr	2,444	Source: Greenhouse Gas Emissions from a Typical Passenger Vehicle, EPA
PM 2.5 Emission Rates Per Hour, g/hr	0.02429	Source: Fact #861 February 23, 2015 Idle Fuel Consumption for Selected Gasoline and Diesel Vehicles; "Average Annual Emissions and Fuel Consumption for Gasoline-Fueled Passenger Cars and Light Trucks", EPA420-F-08-024, October 2008
Conversion rate for Metric tons to Short Tons	1.1015	December 2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs
Grams Per Short Ton	907,185	
Grams Per Metric Ton	1,000,000	
Safety		
Value per Accident Avoided		
O – No Injury	$3,200	December 2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs
C – Possible Injury	$63,900	December 2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs
B – Non-incapacitating	$125,000	December 2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs
A – Incapacitating	$459,100	December 2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs
K – Killed	$9,600,000	December 2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs

Input	Value	Source
U – Injured (Severity Unknown)	$174,000	December 2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs
# Accidents Reported (Unknown if Injured)	$132,200	December 2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs

5. Benefits Methodology

The methodology used to estimate the benefits of the Project are described in the following sections, along with the associated results.

Safety

The Project would result in safety benefits by reducing the number and severity of automobile accidents along the corridor. The methodology for calculating this benefit is described in this section.

Reduced Roadway Fatalities and Crashes

The Project would institute many safety improvements that would benefit motorists, transit riders, pedestrians, and bicyclists. The improvements would reduce crashes, and thus fatalities, injuries, and property damage. A predictive safety analysis was performed and the number of crashes reduced under the Build Alternative was estimated, broken down into two categories – fatal/injury crashes and property damage only crashes. The estimated crash reduction was distributed across crash severity categories (KABCO scale) based on historic distribution of crashes across severity in the project corridor. Annually, approximately 26.79 accidents will be avoided as a result of the Project, 9.07 of which resulted in injuries. Because the distributions are based on historical values, and not on an individual evaluation of the improvements' impact on each accident type, the resulting values are conservative. It is possible that the safety improvements made could lessen the severity of accidents in addition to reducing the number. The reduction in accidents and the distribution by severity are shown in Exhibit 5 and Exhibit 6.

Exhibit 5: Crash Reduction (2034, analysis median year)

	Crash Reduction by Year		
	Fatal/Injury	PDO	Total Crashes
2034	9.07	17.72	26.79

Source: 2019 Predictive Safety Analysis, AECOM

Exhibit 6: Distribution of Crashes with Fatalities/Injuries and Their Reduction with Build Option

	Fatal	Incapacitating	Minor	Possible	Total
Historical (5-year Average)[1]					
Annual Crashes	2.4	8.4	30.8	56	97.6
Proportion	0.025	0.086	0.316	0.574	1.000
2034 Estimate of Crash Reduction[2]	0.223	0.781	2.862	5.204	9.07

[1] Based on historic crash data along 35th Avenue Corridor between I-10 and Camelback Road
[2] AECOM analysis

This analysis conservatively assumed that one crash results in one injury. The reduced fatalities, injuries, and property damage were valued based on USDOT guidance. Accidents avoided in a single year (2034, the median of the analysis period) and the total over the 20-year period, along with value per accident are shown in Exhibit 7.

The total safety benefits amount to $24.83 million for the Project as a whole, discounted at 7 percent and in 2017 dollars.

Exhibit 7: Avoided Accidents

	Accidents Avoided[1]		Value Per Avoided Accident[2]
	2034	**20-year Total**	
Fatalities	0.22	4.47	$9,600,000
A – Incapacitating	0.78	15.63	$459,100
B – Non-incapacitating	2.86	57.31	$125,000
C – Possible Injury	5.20	104.20	$63,900
O – No Injury	17.72	354.84	$3,200
Total	**26.79**	**536.46**	

[1] AECOM analysis
[2] Benefit-Cost Analysis Guidance for Discretionary Grant Programs, U.S. Department of Transportation, December 2018.

Economic Competitiveness

The Project would produce economic benefits by reducing travel time for automobile users. The methodology for calculating these benefits is described in this section.

Travel Time Savings

Under the Build Alternative, signal timing optimization would allow people to move through the study area more efficiently, specifically during the peak periods. Travel demand model outputs for 2025, 2040, and 2045 No Build and Build Alternatives, were utilized in estimating daily vehicle hours saved during the AM and PM peak periods. Daily vehicle hours saved were converted to annual vehicle hours saved by applying an annual factor of 260 (reflecting weekday peak periods in a year). Annual vehicle hours saved for years between 2025-2040 and 2040-2045 were estimated using straight line interpolation. Average auto occupancy of 1.32 (provided by MAG) was applied to convert annual vehicle hours saved to annual person hours saved. Annual person hours saved were multiplied by the value of time ($14.80 in 2017 dollars, for personal travel. See Exhibit 8).

The total time savings amounts to $14.03 million for the Project as a whole, in 2017 dollars and discounted to 2019 at 7 percent.

Exhibit 8: Travel Time Savings ($2017)

	2034 (One-Year)	20-Year Total
VHT Savings[1]	93,380	1,955,063
Total Person Hours Saved[2]	123,261	2,457,616
Value of Hours Saved (Not Discounted)[3]	$1,824,266	$36,372,710
Value of Hours Saved (Discounted at 7%)	$661,198	$14,029,586

[1] AECOM traffic modeling for the project area

[2] Assumes 1.32 persons per vehicle. Average Auto Occupancy, 2019; Maricopa Association of Governments.

[3] Assumes value of $14.80 per hour, for personal trips. Benefit-Cost Analysis Guidance for Discretionary Grant Programs, U.S. Department of Transportation, December 2018.

Environmental Sustainability

The project would reduce harmful automobile emissions caused by vehicle idling. The methodology for calculating these benefits is described in this section.

Reduced Emissions

As the Project improves travel time along the corridor, it will reduce vehicle idling and therefore reduce emissions of Nitrous Oxide (N_2O), Carbon Dioxide (CO_2), Volatile Organic Compounds (VOCs), and Particulate Matter ($PM_{2.5}$).

The estimated reduction in travel time was used to derive total vehicle hours saved. Auto emission rates were applied to vehicle hours saved to calculate the amount of emissions avoided in short tons (N_2O, VOCs, and $PM_{2.5}$) or metric tons (CO_2). The tons of emissions reduced were monetized using the recommended value of emissions from 2018 USDOT guidance (see Exhibit 9).

The total emission benefits amount to $0.04 million for the Project as a whole, discounted at 7 percent and in 2017 dollars.

Exhibit 9: Emissions Reduced

	Hours of Travel Delay Avoided (VHT) [1]		Reduction per hour	Emissions Reduced (Indicated Unit)		Value per Unit[4]
	2034	20-year Total	g/hr	2034	20-year Total	
VOC Short Tons[2]	9,338,000	186,183,000	3.10	0.32	6.36	$2,000
N_2O Short Tons[2]			3.67	0.38	7.54	$8,300
CO_2 Metric Tons[3]			2,443.93	228.21	4,550.17	Varies
$PM_{2.5}$ Short Tons[2]			0.02	0.00	0.05	$377,800

[1] AECOM traffic modeling for the project area
[2] Emissions per hour source. "Idling Vehicle Emissions for Passenger Cars, Light-Duty Trucks, and Heavy-Duty Trucks Emission Facts", EPA420-F-08-205, October 2008
[3] Greenhouse Gas Emissions from a Typical Passenger Vehicle, EPA
[4] Benefit-Cost Analysis Guidance for Discretionary Grant Programs, U.S. Department of Transportation, December 2018

State of Good Repair

Residual Value

The Project improvements retain value at the end of the 20-year analysis period, because their useful life exceeds that of the analysis period. The estimated itemized construction costs are broken down by components, including streetlights/electrical and powerline, roadway/street, and signals/fiber, and the useful life of each (45, 60, and 40, respectively) are used to depreciate the asset to the end of the analysis period using a straight line depreciation method (see Exhibit 10). [2] Right of way (ROW) does not depreciate and retains its full value.

The value of the remaining useful life for the Project amounts to $1.14 million for the Project as a whole, discounted at 7 percent.

Exhibit 10: Residual Value of Construction

	Useful Life (Years)[1]	2017 $	Useful Life Remaining at End of Analysis Period	Remaining Value in 2044 ($2017)	Discounted at 7%
ROW (Does not Depreciate)		$1,912,160	100%	$1,912,160	$352,314
Streetlights, electrical and powerline related	45	$3,559,368	56%	$1,977,427	$364,339
Roadway/street related (medians)	60	$575,763	67%	$383,842	$70,723
Signals, fiber, ITS related	40	$3,838,421	50%	$1,919,211	$353,613
Total		**$9,885,712**		**$6,192,639**	**$1,140,989**

[1] BEA Rate of Depreciation, Service Lives, Declining-Balance Rates, and Hulten-Wykoff Categories

6. Costs

The Project has two cost components: the initial capital costs and the ongoing operating and maintenance (O&M) costs. The components used in this analysis are described in this section.

Capital Costs

The capital costs for the Project include the costs for design, right-of-way acquisition, environmental, streetlights and signals, fees, testing and materials, utility adjustments, and construction and related administration (see Exhibit 11). The capital costs are applied over each element's construction periods, beginning in 2020 and ending in 2024 (see Exhibit 12). Capital costs were provided in 2019 dollars and converted to 2017 dollars using the US GDP deflator. It is estimated that each element's costs are expended equally over the construction periods.

The total capital costs amounted to $18.58 million for the Project as a whole, discounted to 2019 at 7 percent.

Exhibit 11: Capital Costs ($2017)

Project Cost Breakdown	Total (2017$)
Pre-Design Study	$71,948
Design	$1,851,252
Design Administration	$1,907,930
ROW Acquisition	$1,912,160
Environmental	$191,861
Streetlights and Signals	$3,516,806
T2050 Prior Rights Fee	$176,688
Testing and Materials	$123,456
Utility Adjustments	$617,084
Construction	$8,827,651
Construction Administration	$2,607,102
Total	**$21,803,937**

Source: AECOM analysis

Exhibit 12: Capital Costs by Year (2017$)

Year	Total Capital Costs (2017$)	Discounted Capital Total (7%)
2019		$0
2020	$7,906,871	$7,389,599
2021	$4,843,667	$4,230,646

Year	Total Capital Costs (2017$)	Discounted Capital Total (7%)
2022	$3,292,145	$2,687,371
2023	$3,292,145	$2,511,562
2024	$2,469,109	$1,760,441
Total	**$21,803,937**	**$18,579,619**

Source: AECOM analysis

Annual Operating and Maintenance Costs

The Project requires annual and periodic Operating and Maintenance (O&M) expenditures to maintain the improvements. The cost of these expenditures under the Build Alternative was subtracted from O&M expenditures under the No Build Alternative (provided in 2019 dollars). O&M costs for the Project are estimated to exceed the current O&M costs. This net value is then converted to 2017 dollars and applied as an annual cost during the analysis period (see Exhibit 13).

The net O&M cost over the analysis period amounts to $0.63 million for the Project in 2017 dollars and discounted to 2019 at 7 percent.

Exhibit 13: Operations and Maintenance Costs

Annual Baseline O&M Costs for Project Area (without project implementation)	$ 313,232.00	in 2019$
Annual Build O&M Costs for Project Area (with project implementation)	$ 398,351.00	in 2019$
Net O&M Costs	$ 85,119.00	in 2019$
Net O&M Costs	$ 81,654.94	in 2017$

Source: AECOM analysis

7. BCA Results

Based on the analysis, the Benefit Cost Ratio (BCR) for the Project improvements is 2.12, discounted at 7 percent. This demonstrates a good return on investment for the Project. Exhibit 14 shows the results.

Exhibit 14: BCA Results

	7% Discount Rate
Costs (2017 $M)	
Capital Cost	$18.58
Total Costs	*$18.58*
Benefits (2017 $M)	
Safety Benefits	
Reduced Roadway Fatalities and Crashes	$24.83
Environmental Sustainability Benefits	
Emission Savings	$0.04
Economic Competitiveness Benefits	
Travel Time Savings	$14.03
State of Good Repair Benefits	
Residual Savings	$1.14
Net Operating & Maintenance Costs	-$0.63
Total Benefits	*$39.41*
Outcome	
Net Benefits (2017 $M)	$20.83
Benefit-Cost Ratio	**2.12**

Source: AECOM Analysis

Appendix A List of Supporting Documents

USDOT 2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs, https://www.transportation.gov/sites/dot.gov/files/docs/mission/office-policy/transportation-policy/284031/benefit-cost-analysis-guidance-2018.pdf

White House Office of Management and Budget. Historical Tables, Table 10.1 – Gross Domestic Product and Deflators Used in the Historical Tables 1940-2024. https://www.whitehouse.gov/omb/budget/Historicals

U.S. Environmental Protection Agency “Greenhouse Gas Emissions from a Typical Passenger Vehicle,” https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100U8YT.pdf

U.S. Environmental Protection Agency "Idling Vehicle Emissions for Passenger Cars, Light-Duty Trucks, and Heavy-Duty Trucks Emission Facts", EPA420-F-08-205, 2008

Bureau of Economic Analysis,“Rate of Depreciation, Service Lives, Declining-Balance Rates, and Hulten-Wykoff Categories,” http://www.bea.gov/scb/account_articles/national/wlth2594/tableC.htm

Phoenix_35Avenue_BUILD2019_BCA excel workbook

2019 Predictive Safety Analysis, AECOM (35th Ave Predictive Safety Analysis Memo.pdf)