

# **Benefit Cost Analysis of Archer Avenue at Belt Railway of Chicago Grade Separation Project**

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Prepared for:



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## TABLE OF CONTENTS

<b>I.</b>	<b>INTRODUCTION.....</b>	<b>1</b>
I.1	ARCHER AVENUE AT BELT RAILWAY OF CHICAGO GRADE SEPARATION PROJECT .....	1
I.2	BENEFIT COST ANALYSIS (BCA) MODEL DEVELOPMENT .....	1
I.3	ORGANIZATION OF BCA MEMORANDUM .....	2
<b>II.</b>	<b>PROJECT BENEFITS AND COSTS .....</b>	<b>3</b>
II.1	BENEFITS OF THE PROJECT .....	3
II.2	COSTS OF THE PROJECT .....	4
II.3	RESIDUAL VALUE.....	4
<b>III.</b>	<b>GS9 INPUTS .....</b>	<b>4</b>
III.1	PERIOD OF ANALYSIS .....	4
III.2	BASE YEAR OF ANALYSIS .....	4
III.3	ROADWAY VOLUMES .....	5
III.4	GATE DOWN TIME .....	6
III.5	CRASH DATA .....	6
III.6	FIRST RESPONDER IMPACTS .....	9
III.7	IDLING IMPACTS .....	9
III.8	WEATHER-RELATED MAINTENANCE .....	10
<b>IV.</b>	<b>BENEFIT–COST ANALYSIS METHODOLOGY .....</b>	<b>10</b>
IV.1	TRAFFIC DELAY COST SAVINGS .....	10
IV.2	REDUCED CRASH EXPOSURE .....	11
IV.3	AVOIDED FIRST RESPONDER DELAY .....	12
IV.4	AVOIDED TRAFFIC IDLING .....	14
IV.5	AVOIDED CROSSING MAINTENANCE .....	16
<b>V.</b>	<b>BENEFIT–COST ANALYSIS RESULTS .....</b>	<b>17</b>
V.1	QUANTIFIED BENEFITS.....	17
V.2	UNQUANTIFIED BENEFITS .....	17
<b>APPENDIX A</b>	<b>.....</b>	<b>A-I</b>
<b>APPENDIX B</b>	<b>.....</b>	<b>B-I</b>

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## TABLES

TABLE 1: PROJECT MATRIX.....	3
TABLE 2: PROJECT COSTS .....	4
TABLE 3: CONSTRUCTION PROJECT SCHEDULE .....	4
TABLE 4: LOCAL TRAFFIC.....	5
TABLE 5: TRANSIT USERS.....	5
TABLE 6: GATE DOWN TIME.....	6
TABLE 7: AVERAGE RAIL-RELATED CRASH COST.....	7
TABLE 8: HISTORICAL REAR-END CRASHES AT GS9 .....	7
TABLE 9: AVERAGE REAR-END CRASH COST .....	8
TABLE 10: OTHER CRASHES AT GS9 .....	8
TABLE 11: AVERAGE OTHER CRASH COST .....	9
TABLE 12: IDLING FUEL CONSUMPTION .....	9
TABLE 13: TRAFFIC DELAY COST SAVINGS BENEFIT .....	10
TABLE 14: REDUCED CRASH EXPOSURE BENEFIT.....	11
TABLE 15: AVOIDED FIRST RESPONDER DELAY BENEFIT .....	12
TABLE 16: AVOIDED TRAFFIC IDLING BENEFIT .....	14
TABLE 17: AVOIDED CROSSING MAINTENANCE BENEFIT .....	16
TABLE 18: DISCOUNTED BENEFITS AND COSTS FOR THE PROJECT (IN MILLIONS).....	17
TABLE A-1: VALUE OF TIME FACTOR (2019 DOLLARS).....	A-II
TABLE A-2: AVERAGE VEHICLE OCCUPANCY FACTOR .....	A-II
TABLE A-3: GDP GROWTH FACTOR (FY) .....	A-III
TABLE A-4: BCA VALUE OF REDUCED FATALITIES AND INJURIES (2019 DOLLARS) .....	A-III
TABLE A-5: EMS-RELATED FORMULAS AND PARAMETERS.....	A-IV
TABLE A-6: FIRE-RELATED FORMULAS AND PARAMETERS.....	A-IV
TABLE A-7: HOSPITAL-RELATED FORMULAS AND PARAMETERS .....	A-IV
TABLE A-8: EMISSIONS RATE FACTORS .....	A-V
TABLE A-9: BCA EMISSIONS COST FACTORS (2019 DOLLARS) .....	A-VI
TABLE A-10: FUEL COST (2019 DOLLARS) .....	A-VII
TABLE B-1: BCA SUMMARY .....	B-II

## FIGURES

FIGURE 1: GS9 PROJECT AREA .....	2
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## ACRONYMS

AIS	Abbreviated Injury Scale
BCA	Benefit Cost Analysis
B/C	Benefit-Cost Ratio
BRC	Belt Railway of Chicago
CARB	California Air Resources Board
CMAP	Chicago Metropolitan Agency for Planning
CO2	Carbon Dioxide
CREATE	Chicago Region Environmental and Transportation Efficiency Program
CAGR	Cumulative Annual Growth Rate
CTA	Chicago Transit Authority
EMFAC	Emission Factors
EMS	Emergency Medical Services
EPA	Environmental Protection Agency
FRA	Federal Railroad Administration
GDP	Gross Domestic Product
GS9	Archer Avenue at Belt Railway of Chicago Grade Separation Project
MPH	Miles Per Hour
NOx	Nitrogen Oxides
NPV	Net Present Value
O&M	Operating and Maintenance
PDO	Property Damage Only
PM2.5	Particulate Matter
SCC	Standard Cost Category
USDOT	United States Department of Transportation
VHT	Vehicle Hours Traveled
VH	Vehicle Hours
VMT	Vehicle Miles Traveled
VOT	Value of Time

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## I. INTRODUCTION

This report documents the Benefit Cost Analysis (BCA) that evaluates the benefits to society resulting from the Archer Avenue at Belt Railway of Chicago Grade Separation Project. The BCA demonstrates the cost effectiveness of the Project measured in terms of a Benefit–Cost (B/C) ratio and Net Present Value (NPV).

### *I.1 Archer Avenue at Belt Railway of Chicago Grade Separation Project*

The Archer Avenue and Belt Railway of Chicago (BRC) Grade Separation Project (defined as “GS9”) proposes a grade separation to eliminate road-rail conflicts at a busy railroad crossing designated as a "911 Critical Crossing" by the City of Chicago. The project is one railroad project among 70 developed and pursued by the public and private partners in the Chicago Region Environmental and Transportation Efficiency (CREATE) Program that have completed 31 projects to date. Next in line, the GS9 project will increase the safety and efficiency of a railroad network that serves \$641 billion in goods movement across the nation. In addition, the GS9 project will improve safety and air quality for local residents in the project location with a population that has a high proportion of racial minorities.

### *I.2 Benefit Cost Analysis (BCA) Model Development*

The Benefit Cost Analysis is based on traffic and transit delay, crash exposure, first responder delays, avoided idling impacts, and reduced crossing maintenance costs associated with GS9 in the Build and No-Build scenarios.

A spreadsheet-based BCA model was constructed for the purposes of this analysis. The model utilizes various region or corridor specific statistics in addition to global parameters provided by the United States Department of Transportation (USDOT) specifically for the purposes of completing BCAs in support of federal grant applications. Project specific inputs are discussed in Section III. Global parameters as defined by the USDOT are shown in Appendix A.

Using both Project-specific inputs and global parameters, the BCA model calculates life-cycle costs, life-cycle benefits, annual benefits, the NPV of quantifiable costs and benefits, and the resulting B/C ratio, utilizing a methodology that aligns with the most recent USDOT guidance.

Figure 1: GS9 Project Area



### ***1.3 Organization of BCA Memorandum***

Section II describes the mechanisms that generate the benefits of the Project and the classes of benefits evaluated.

Section III describes the inputs to the BCA model.

Section IV describes the detailed methodology for computing Project benefits, including an illustration of the benefits calculated for an example year for the Project.

Section V summarizes the BCA results and the resulting B/C ratio.

Appendix A provides the global parameters used in the BCA.

Appendix B provides detailed tabulations of annual benefits and costs for the overall Project.

## II. PROJECT BENEFITS AND COSTS

### II.1 *Benefits of the Project*

The following benefits are quantified for this analysis:

1. Reduced Traffic Delay
2. Reduced Crash Exposure
3. Reduced First Responder Delay
4. Avoided Idling Impacts
5. Avoided Crossing Maintenance

The methodology for evaluating each of these benefits is discussed in Section IV.

**Table 1: Project Matrix**

Current Status / Baseline and Problem to be Addressed	This Project will eliminate an at-grade crossing to reduce roadway congestion and delay for local traffic, trucks, and first responders and improve safety at the location by eliminating crashes between vehicles and trains.
Change to Baseline / Alternatives	Build Scenario includes the construction of a grade-separated crossing on Archer Avenue.
Type of Impacts	Reduced vehicle delay from eliminated gate down time. Reduced crash exposure. Reduced first responder delay from eliminated gate down time. Avoided idling impacts. Reduced crossing maintenance costs.
Affected Population	Local traffic, transit users, first responders.
Economic Benefit	The BCA indicates that the Project will result in travel time savings associated with a reduction in travel time delay. The Project will also result in crash savings resulting from the eliminated at-grade crossing.
Summary of Results	Benefit/Cost ratio greater than 1.00 indicates that the Project generates quantified benefits to society that exceed its costs.

## II.2 Costs of the Project

Project costs used in this analysis are estimated in 2020 dollars and converted to 2019 base year dollars using a GDP deflator as summarized in Table 2 by phase.

Additional costs such as incremental operating costs are considered "Other Costs" and are deducted from the total benefits for the benefit-cost ratio calculation. For this analysis, no additional costs are considered.

Table 2: Project Costs

Total Capital Cost	Total Cost	Units
Phase I Preliminary Engineering	\$1,600,000	2020\$
Phase II Design	\$9,500,000	2020\$
Phase III Construction	\$50,000,000	2020\$
Total Project Cost	\$61,100,000	2020\$
Undiscounted Cost	\$60,012,811	2019\$
Discounted Cost (7%)	\$43,335,451	2019\$

## II.3 Residual Value

The residual value of the project is estimated based on an estimated 75 year useful life of all project elements and added to the project benefits for calculating the B/C Ratio and NPV.

## III. GS9 INPUTS

### III.1 Period of Analysis

This analysis considers a 30-year analysis period beginning in the opening year of the Project.

Table 3: Construction Project Schedule

Factor	Year
Improvement Construction Start	2024
Improvement Opening Year	2026

### III.2 Base Year of Analysis

Per USDOT BCA guidance, this analysis is conducted in constant 2019 dollars. All costs and benefits are discounted to 2019 at a 7% discount rate except for carbon-related benefits which are discounted at 3%.

### III.3 Roadway Volumes

The following inputs are used to estimate the impacted roadway users at the existing at-grade crossing.

#### III.3.1 Local Traffic

To estimate the time savings realized by roadway users at the crossing, 2017 traffic counts and forecast traffic volumes from the Chicago Metropolitan Agency for Planning (CMAP) regional travel demand model are used, as summarized in Table 4. This analysis assumes that traffic volumes will remain constant after year 2040 and that there are no new or induced trips resulting from the Project.

Table 4: Local Traffic

Factor	Value	Units
Traffic Volume		
2017	19,800	vehicles/day
2040	21,100	vehicles/day
Truck Percentage	12%	percent
Traffic CAGR	0.28%	percent
Annualization Factor	365	days/year

Source: CDOT GS9 Project Development Report, 2018. Page 6

#### III.3.2 Transit Users

To estimate the time savings realized by transit users travelling through the at-grade crossing, transit volumes from the Chicago Transit Agency (CTA) are used along with an assumed 5% passenger load through the crossing and a weekday-only annualization factor to be conservative. The transit-related inputs are summarized in Table 5.

Table 5: Transit Users

Factor	Value	Units
Total Corridor Ridership	11,286	persons/day
Assumed Passenger Load Percentage	5%	percent
Annualization Factor	255	days/year

Source: RTAMS 2019 ridership, assumes 5% passenger load at crossing and 255 annualization factor to be conservative

### III.4 Gate Down Time

By eliminating the at-grade crossing, all travel delays associated with the existing gate down time will be eliminated for local traffic, transit users, and first responders. Train volume is based on a 2020 train count provided by Belt Railway of Chicago, which is consistent with volumes observed in 2017 and is less than the 54 trains per day reflected in FRA's Grade Crossing Inventory database. The train volume is assumed to grow based on the CMAP freight forecast.

Average gate down time is based on a 24-hour observation in June 2017 of 2:07:33 hours per day that is considered by stakeholders to remain representative of conditions at the project location. To estimate the average wait time experienced by users at a crossing, the average gate down time is divided by two. The total gate down time is also used to estimate the probability of a roadway user encountering a train at the crossing. Crossing gate-related inputs are summarized in Table 6.

Table 6: Gate Down Time

Factor	Value	Units
Train Volume	25	<i>trains/day</i>
Freight CAGR	1.52%	<i>percent</i>
Average Gate Down Time	5.10	<i>minutes</i>
Average Delay Time	2.55	<i>minutes/person</i>

Source: Train count provided by BRC , 2021. Compares to 54 trains per day in FRA Grade Crossing Inventory and 25 trains/day in CDOT GS9 Project Development Report, 2018.

### III.5 Crash Data

The following inputs are used to estimate the avoided crash exposure resulting from the Project and the typical crash severity at the existing at-grade crossing. Three types of crashes are quantified for this analysis: rail-related crashes, rear-end crashes, and other traffic crashes at the crossing.

#### III.5.1 Rail-Related Crashes

The likelihood of a crash occurring in the No-Build scenario is obtained from the FRA Web Accident Prediction System which predicts 0.0642 annual crashes at the crossing, growing at the same rate as the freight CAGR. This crash probability is a conservative assumption when compared to the crash history at the crossing: 15 crashes since 1976. In the Build scenario, all crashes between vehicles and trains are eliminated.

To estimate the average severity of crashes occurring at the crossing, FRA historical crash data for Cook County is applied to USDOT-provided unit costs for fatalities, injuries, and property damage, as summarized in Table 7. The logic for using a wider network-wide to estimate the average crash severity is to account for the possibility of a more severe crash incident even if one has not been recorded at GS9 in recent history. This analysis assumes one vehicle per rail-related crash and that the crash impacts on trains are negligible.

Table 7: Average Rail-Related Crash Cost

Input	2030 Value	Units
<b>Crash History<sup>A</sup></b>		
a Crashes	480	<i>total crashes</i>
b Injuries	184	<i>total injuries</i>
c Fatalities	60	<i>total fatalities</i>
d Average Vehicles per Crash	1	<i>vehicles/crash</i>
<b>Monetization<sup>B</sup></b>		
e Crashes	\$4,500	<i>2019\$/vehicle</i>
f Injuries	\$197,600	<i>2019\$/injury</i>
g Fatalities	\$10,900,000	<i>2019\$/fatality</i>
h Average Crash Cost	$((a * d * e) + (b * f) + (c * g)) / a$	\$1,442,747 <i>2019\$/crash</i>

Source: A: FRA Office of Safety Analysis. 1.12 Ten-Year Accident/Incident Overview - Cook County, IL (2010-2019). Accessed at <https://safetydata.fra.dot.gov/OfficeofSafety/publicsite/Query/TenYearAccidentIncidentOverview.aspx>

Source: B: U.S. Department of Transportation, Benefit Cost Analysis Guidance for Discretionary Grant Programs, Feb 2021. See Table A-4 on page III of Appendix A

### III.5.II Rear-End Crashes

The likelihood of a rear-end crash occurring in the No-Build scenario is obtained from IDOT crash records at the crossing between 2010 and 2016 and grows at the same rate as the traffic CAGR. The crash history is summarized in Table 8. In the Build scenario, all rear-end crashes are eliminated.

Table 8: Historical Rear-End Crashes at GS9

Input	Value	Units
<b>Crash History</b>		
a Crashes	78	<i>total crashes</i>
b Injuries	19	<i>total injuries</i>
c Fatalities	0	<i>total fatalities</i>
d Years of Data	7	<i>years</i>
e Annual Crashes	$a / d$	11.14 <i>crashes/year</i>

Source: IDOT. 2010-2016 Crash Detail Summary at Belt Railway of Chicago at Approx. 5266 South Archer Ave. GS9 Crash Analysis at Archer BRC RR.pdf

To estimate the average severity of rear-end crashes occurring at the crossing, historical IDOT crash data is applied to USDOT-provided unit costs for fatalities, injuries, and property damage, as summarized in Table 9. This analysis assumes two vehicles per crash.

Table 9: Average Rear-End Crash Cost

Input	2030 Value	Units
<b>Crash History</b>		
a Crashes	78	<i>total crashes</i>
b Injuries	19	<i>total injuries</i>
c Fatalities	0	<i>total fatalities</i>
d Average Vehicles per Crash	2	<i>vehicles/crash</i>
<b>Monetization<sup>A</sup></b>		
e Crashes	\$4,500	<i>2019\$/vehicle</i>
f Injuries	\$197,600	<i>2019\$/injury</i>
g Fatalities	\$10,900,000	<i>2019\$/fatality</i>
h Average Crash Cost	$((a * d * e) + (b * f) + (c * g)) / a$	\$57,133 <i>2019\$/crash</i>

Source: A: U.S. Department of Transportation, Benefit Cost Analysis Guidance for Discretionary Grant Programs, Feb 2021. See Table A-4 on page III of Appendix A

### III.5.III Other Crashes at Crossing

The likelihood of additional crashes (those not involving trains or rear-end crashes) occurring at the crossing in the No-Build scenario is obtained from IDOT crash records at the crossing between 2010 and 2016 and grows at the same rate as the traffic CAGR. The crash history is summarized in Table 10. In the Build scenario, all crashes at the crossing are eliminated.

Table 10: Other Crashes at GS9

Input	Value	Units
<b>Crash History</b>		
a Crashes	23	<i>total crashes</i>
b Injuries	9	<i>total injuries</i>
c Fatalities	0	<i>total fatalities</i>
d Years of Data	7	<i>years</i>
e Annual Crashes	$a / d$	3.29 <i>crashes/year</i>

Source: IDOT. 2010-2016 Crash Detail Summary at Belt Railway of Chicago at Approx. 5266 South Archer Ave. GS9 Crash Analysis at Archer BRC RR.pdf

To estimate the average severity of other crashes occurring at the crossing, historical IDOT crash data is applied to USDOT-provided unit costs for fatalities, injuries, and property damage, as summarized in Table 11. This analysis assumes two vehicles per crash.

Table 11: Average Other Crash Cost

Input	2030 Value	Units
<b>Crash History</b>		
a Crashes	23	<i>total crashes</i>
b Injuries	9	<i>total injuries</i>
c Fatalities	0	<i>total fatalities</i>
d Average Vehicles per Crash	2	<i>vehicles/crash</i>
<b>Monetization<sup>A</sup></b>		
e Crashes	\$4,500	<i>2019\$/vehicle</i>
f Injuries	\$197,600	<i>2019\$/injury</i>
g Fatalities	\$10,900,000	<i>2019\$/fatality</i>
h Average Crash Cost	$((a * d * e) + (b * f) + (c * g)) / a$	\$86,322 <i>2019\$/crash</i>

Source: A: U.S. Department of Transportation, Benefit Cost Analysis Guidance for Discretionary Grant Programs, Feb 2021. See Table A-4 on page III of Appendix A

### III.6 First Responder Impacts

To represent the community impacted by first responder delays, this analysis uses the population of census tracts within a half mile of the GS9 crossing. Based on the US Census, the impacted population is 17,564 persons.

### III.7 Idling Impacts

To estimate the impact of reduced idling time at the crossing, this analysis considers the reduction in fuel cost to users and the value of avoided emissions costs. Both impacts are driven by the rate of fuel consumption while idling, as summarized in Table 12. Both fuel consumption rates and emission rates are assumed to change over time to reflect changes in vehicle technology and fleet composition based on forecasts from the California Air Resources Board (CARB), as described in Section A-VI. Emissions Rates on page V in Appendix A.

Table 12: Idling Fuel Consumption

Factor	Value	Units
Passenger Vehicle	0.39	<i>gallons/hour</i>
Truck	0.90	<i>gallons/hour</i>

Source: Argonne National Laboratory, Idling Reduction Savings Calculator. Accessed at [https://www.anl.gov/sites/www/files/2018-02/idling\\_worksheet.pdf](https://www.anl.gov/sites/www/files/2018-02/idling_worksheet.pdf)

### III.8 Weather-Related Maintenance

To estimate the benefits associated with the reduction in weather-related maintenance at the crossing, this analysis assumes eight man hours of maintenance for each snow fall. According to the National Oceanic & Atmospheric Administration, the average number of days of snowfall for the area is 27 days a year. The fully-loaded cost of maintenance is assumed to be \$65 per man-hour, growing annually with a GDP growth factor to account for growth.

## IV. BENEFIT–COST ANALYSIS METHODOLOGY

### IV.1 Traffic Delay Cost Savings

The traffic delay cost savings for roadway users crossing GS9 are driven by the eliminated gate-down delay. The train volume and average gate down time are used to develop a delay probability which is then applied to the average delay time for all roadway users using USDOT-provided factors for value of time. Table 13 describes the methodology used to calculate the undiscounted benefit and shows the undiscounted benefit for the year 2026 as an example.

Table 13: Traffic Delay Cost Savings Benefit

Input		2026 Value	Units
<b>TRAFFIC VOLUME<sup>A</sup></b>			
a	Transit Ridership	143,895	passengers/year
b	Annual Traffic	7,409,089	vehicles/year
c	Truck Percentage	12%	percent
d	Passenger Vehicle	$b * (1 - c)$	6,519,998 vehicles/year
e	Truck	$b * c$	889,091 trucks/year
<b>GATE DOWN TIME<sup>B</sup></b>			
f	Gate Down Time	140	minutes/day
g	Delay Probability	$f / 24 / 60$	9.69% %
h	Average Delay Time	0.04	hours
<b>DELAY BY MODE</b>			
<b>Vehicle Occupancy<sup>C</sup></b>			
i	Passenger Vehicle	1.67	persons/automobile
j	Truck	1.00	persons/truck
<b>Avoided Vehicle Delay</b>			
k	Passenger Vehicle Delay	$d * g * h$	26,874 vehicle-hours/year
l	Truck Delay	$e * g * h$	3,665 vehicle-hours/year
<b>Avoided Person Delay</b>			
m	Transit	$a * g * h$	593 person-hours/year
n	Passenger Vehicle	$i * k$	44,880 person-hours/year
o	Truck Driver	$j * l$	3,665 person-hours/year

Input		2026 Value	Units
<b>VALUE DELAY SAVINGS</b>			
<b>Value of Travel Time<sup>D</sup></b>			
p	In-Vehicle Travel, All Purposes	\$20.28	2019\$/hour
q	Truck Drivers	\$34.89	2019\$/hour
<b>Value of Avoided Delay</b>			
r	Transit	m * p	\$12,027 2019\$/year
s	Passenger Vehicle	n * p	\$910,031 2019\$/year
t	Truck Driver	o * q	\$127,860 2019\$/year
Total Value of Benefit		r + s + t	\$1,049,918 2019\$/year

Source: A. See Table 4: Local Traffic and Table 5: Transit Users on page 5

Source: B. See Table 6: Gate Down Time on page 6

Source: C. See Table A-2: Average Vehicle Occupancy Factor on page II

Source: D. See Table A-1: Value of Time Factor (2019 Dollars) on page II

## IV.2 Reduced Crash Exposure

The benefit associated with the crash exposure reduction at GS9 is estimated by applying the expected annual crashes to the average crash cost based on average crash severity for each of the three crash types: rail-related crashes, rear-end crashes, and other crashes at the crossing. Table 14 describes the methodology used to calculate the undiscounted benefit and shows the undiscounted benefit for each year of the analysis.

**Table 14: Reduced Crash Exposure Benefit**

Input		2026 Value	Units
<b>RAIL-RELATED CRASHES<sup>A</sup></b>			
a	Annual Crashes	0.0703	crashes/year
b	Average Crash Cost	\$1,442,747	2019\$/crash
<b>REAR-END CRASHES<sup>B</sup></b>			
c	Annual Crashes	11.424	crashes/year
d	Average Crash Cost	\$57,133	2019\$/crash
<b>OTHER CROSSING CRASHES<sup>C</sup></b>			
e	Annual Crashes	3.369	crashes/year
f	Average Crash Cost	\$86,322	2019\$/crash
Total Value of Benefit		(a * b) + (c * d) + (e * f)	\$1,044,845 2019\$/year

Source: A. See Section III.5.I Rail-Related Crashes on page 6

Source: B. See Section III.5.II Rear-End Crashes on page 7

Source: C. See Section III.5.III Other Crashes at Crossing on page 8

### IV.3 Avoided First Responder Delay

To estimate the first responder impacts to the surrounding community as a result of delays at GS9, FEMA-developed methodologies for fire response, EMS, and hospital access are adapted for this type of project. To be conservative, no growth in population over the analysis period is assumed. Table 15 describes the methodology used to calculate the undiscounted benefit and shows the undiscounted benefit for the year 2026 as an example.

Table 15: Avoided First Responder Delay Benefit

Input		2026 Value	Units
<b>IMPACTED COMMUNITY</b>			
a	Communed Population <sup>A</sup>	17,564	persons
<b>GATE DOWN TIME<sup>B</sup></b>			
b	Gate Down Time	140	minutes/day
c	Delay Probability	$b / 24 / 60$	9.69% %
d	Average Delay Time	0.04	hours
<b>FIRE RESPONSE-RELATED BENEFITS<sup>C</sup></b>			
<b>Fire Response Time</b>			
e	Build		5 minutes
f	No-Build	$e + c * d * 60$	5.25 minutes
<b>Potential Fire Incidents</b>			
j	Incidents per Year	$a * 0.0055$	96.60 incidents/year
<b>Probability of No-Loss Incident</b>			
g	No Build	$0.456 - 0.00264 * f$	0.4421
h	Build	$0.456 - 0.00264 * e$	0.4428
<b>Average Property Dollar Loss</b>			
i	No Build	$3845 + 431 * f$	\$6,107 1993\$/incident
j	Build	$3845 + 431 * e$	\$6,000 1993\$/incident
k	No Build	$i / 0.63$	\$9,693 2019\$/incident
l	Build	$j / 0.63$	\$9,524 2019\$/incident
<b>Avoided Cost</b>			
m	Property Dollar Loss	$((1 - g) * k) - ((1 - h) * l) * j$	\$9,718 2019\$/year
n	Indirect Loss	$m * 0.1$	\$972 2019\$/year
o	Mortality and Injury Loss	$(m + n) * 3.3$	\$35,278 2019\$/year
p	Total Fire-Related Benefits	$m + n + o$	\$45,968 2019\$/year

Input		2026 Value	Units
<b>EMS-RELATED BENEFITS<sup>D</sup></b>			
<b>EMS Response Time</b>			
q	Build		7 minutes
r	No-Build	$q + c * d * 60$	7.25 minutes
<b>Potential Cardiac Arrests</b>			
j	Incidents per Year	$a * 58.5 / 100,000$	10.27 incidents/year
<b>Survival Probability</b>			
s	No Build	$(1 + e^{-0.260 + 0.106 * (r + 1) + 0.139 * (r + 2)})^{-1}$	0.1302
t	Build	$(1 + e^{-0.260 + 0.106 * (q + 1) + 0.139 * (q + 2)})^{-1}$	0.1372
<b>Potential Deaths</b>			
u	No Build	$j * (1 - s)$	8.94 persons/year
v	Build	$j * (1 - t)$	8.87 persons/year
w	Avoided Deaths	$v - u$	0.07 persons/year
<b>Avoided Cost</b>			
x	Value of Fatality <sup>E</sup>	\$10,900,000	2019\$/fatality
y	Total EMS-Related Benefits	$w * x$	\$785,642 2019\$/year
<b>HOSPITAL-RELATED BENEFITS<sup>F</sup></b>			
<b>Potential Deaths</b>			
z	AMI	$a * 50.9 / 100,000$	8.94 persons/year
aa	Unintended Injury	$a * 39.7 / 100,000$	6.97 persons/year
<b>Delay Impact</b>			
ab	Typical Driving Speed		30 mph
ac	Average Delay Time	d	0.04 hours
ad	Equivalent Distance	$ab * ac$	1.275 miles
<b>Increase in Deaths</b>			
ae	AMI	$c * z * ad * 0.0604$	0.067 persons/year
af	Unintentional Injury	$c * aa * ad * 0.0614$	0.053 persons/year
<b>Avoided Cost</b>			
ag	Value of Fatality <sup>E</sup>	\$10,900,000	2019\$/fatality
ah	Total Hospital-Related Benefits	$(ae + af) * ag$	\$1,304,873 2019\$/year
<b>ALL BENEFITS</b>			
Total Value of Benefit		$p + y + ah$	\$2,136,483 2019\$/year

Source: A. See Section III.6 First Responder Impacts on page 9

Source: B. See Table 6: Gate Down Time on page 6

Source: C. See Table A-6: Fire-Related Formulas and Parameters on page IV

Source: D. See Table A-5: EMS-Related Formulas and Parameters on page IV

Source: E. See Table A-4: BCA Value of Reduced Fatalities and Injuries (2019 dollars) on page III

Source: F. See Table A-7: Hospital-Related Formulas and Parameters on page IV

#### IV.4 Avoided Traffic Idling

To estimate the benefits associated with the reduced idling at GS9, this analysis quantifies the reduction in fuel cost for users and emissions damage resulting from the reduction in fuel consumption. Table 16 describes the methodology used to calculate the undiscounted benefit and shows the undiscounted benefit for the year 2026 as an example. To calculate the benefit-cost ratio, carbon-related benefits are discounted at 3% per the USDOT BCA guidance.

Table 16: Avoided Traffic Idling Benefit

Input		2026 Value	Units
<b>TRAFFIC VOLUME<sup>A</sup></b>			
a	Transit Ridership	143,895	passengers/year
b	Annual Traffic	7,409,089	vehicles/year
c	Truck Percentage	12%	percent
d	Passenger Vehicle	$b * (1 - c)$	6,519,998 vehicles/year
e	Truck	$b * c$	889,091 trucks/year
<b>GATE DOWN TIME<sup>B</sup></b>			
f	Gate Down Time	140	minutes/day
g	Delay Probability	$f / 24 / 60$	9.69% %
h	Average Delay Time	0.04	hours
<b>FUEL COST REDUCTION</b>			
<b>Fuel Consumption<sup>C</sup></b>			
i	Passenger Vehicle	0.26	gallons/hour
j	Truck	0.77	gallons/hour
<b>Avoided Fuel Consumption</b>			
k	Passenger Vehicle	$d * g * h * i$	6,958.00 gallons/year
l	Truck	$e * g * h * j$	2,829.23 gallons/year
<b>Fuel Cost less tax<sup>D</sup></b>			
m	Gasoline	\$2.56	2019\$/gallon
n	Diesel	\$2.73	2019\$/gallon
<b>Avoided Fuel Cost</b>			
o	Gasoline	$k * m$	\$17,827 2019\$/year
p	Diesel	$l * n$	\$7,717 2019\$/year
q	All Fuel	$o + p$	\$25,544 2019\$/year

Input		2026 Value	Units
<b>EMISSIONS REDUCTION</b>			
<b>Emission Rates (idling = 5mph)<sup>E</sup></b>			
<i>Gasoline</i>			
r	Nitrogen oxides (NOx)	2.04	grams/gallon
s	Sulfur Oxides (SOx)	0.12	grams/gallon
t	Particulate matter (PM2.5)	0.11	grams/gallon
u	Carbon Dioxide (CO2)	12,357	grams/gallon
<i>Diesel</i>			
v	Nitrogen oxides (NOx)	117.70	grams/gallon
w	Sulfur Oxides (SOx)	0.26	grams/gallon
x	Particulate matter (PM2.5)	0.48	grams/gallon
y	Carbon Dioxide (CO2)	29,429	grams/gallon
<b>Avoided Emissions</b>			
<i>Gasoline</i>			
z	Nitrogen oxides (NOx)	$k * r / 10^6$	0.0142 metric tons/year
aa	Sulfur Oxides (SOx)	$k * s / 10^6$	0.0009 metric tons/year
ab	Particulate matter (PM2.5)	$k * t / 10^6$	0.0008 metric tons/year
ac	Carbon Dioxide (CO2)	$k * u / 10^6$	85.98 metric tons/year
<i>Diesel</i>			
ad	Nitrogen oxides (NOx)	$l * v / 10^6$	0.3330 metric tons/year
ae	Sulfur Oxides (SOx)	$l * w / 10^6$	0.0007 metric tons/year
af	Particulate matter (PM2.5)	$l * x / 10^6$	0.0014 metric tons/year
ag	Carbon Dioxide (CO2)	$l * y / 10^6$	83.26 metric tons/year
<i>All Fuel Types</i>			
ah	Nitrogen oxides (NOx)	$z + ad$	0.3472 metric tons/year
ai	Sulfur Oxides (SOx)	$aa + ae$	0.0016 metric tons/year
aj	Particulate matter (PM2.5)	$ab + af$	0.0021 metric tons/year
ak	Carbon Dioxide (CO2)	$ac + ag$	169.24 metric tons/year
<b>Emissions Cost<sup>F</sup></b>			
al	Nitrogen oxides (NOx)	\$17,000	2019\$/metric ton
am	Sulfur Oxides (SOx)	\$45,500	2019\$/metric ton
an	Particulate matter (PM2.5)	\$807,500	2019\$/metric ton
ao	Carbon Dioxide (CO2)	\$57	2019\$/metric ton

Input		2026 Value	Units
<b>Avoided Emissions Cost</b>			
ap	Nitrogen oxides (NOx)	ah * al	\$5,902 2019\$/metric ton
aq	Sulfur Oxides (SOx)	ai * am	\$73 2019\$/metric ton
ar	Particulate matter (PM2.5)	aj * an	\$1,730 2019\$/metric ton
as	Carbon Dioxide (CO2)	ak * ao	\$9,647 2019\$/metric ton
at	All Emissions	ap + aq + ar + as	\$17,352 2019\$/year
<b>ALL BENEFITS</b>			
	Total Value of Benefit	q + at	\$42,896 2019\$/year

Source: A. See Table 4: Local Traffic and Table 5: Transit Users on page 5

Source: B. See Table 6: Gate Down Time on page 6

Source: C. See Table 12: Idling Fuel Consumption on page 9

Source: D. See Table A-10: Fuel Cost (2019 dollars) on page VII

Source: E. See Table A-8: Emissions Rate Factors on page V

Source: F. See Table A-9: BCA Emissions Cost Factors (2019 dollars) on page VI

#### IV.5 Avoided Crossing Maintenance

To estimate the benefits associated with the avoided costs at GS9 resulting from weather-related maintenance, the typical maintenance cost is applied to the average annual snowfall. Table 17 describes the methodology used to calculate the undiscounted benefit and shows the undiscounted benefit for the year 2026 as an example.

Table 17: Avoided Crossing Maintenance Benefit

Input		2026 Value	Units
a	Average Snowfall	26.70	days/year
b	Maintenance Duration	8	hours/day
c	Average Maintenance Cost	\$73.63	2019\$/hour
	Total Value of Benefit	a * b * c	\$15,728 2019\$/year

Source: See Section III.8 Weather-Related Maintenance on page 10

## V. BENEFIT–COST ANALYSIS RESULTS

### V.1 *Quantified Benefits*

The BCA indicates that the Project will result in reduced crash exposure, reduced travel time for roadway users including emergency vehicles, reduced traffic idling impacts, and reduced crossing maintenance cost. The Project produces a benefit/cost ratio greater than 1.00, indicating that the benefits to society exceed the Project's costs. A summary of the discounted base dollar costs and benefits is shown in Table 18.

Appendix B provides detailed tabulations of annual benefits and costs for the Project.

Table 18: Discounted Benefits and Costs for the Project (in millions of 2019\$)

Factor	Value
Reduced Traffic Delay Cost	\$11.96
Reduced Crash Exposure	\$8.92
Reduced First Responder Delay	\$19.95
Avoided Traffic Idling	\$0.55
Avoided Crossing Maintenance	\$0.15
Total Benefits	\$41.54
Other Costs	\$0.00
Residual Value	\$2.95
Net Benefits	\$44.48
Capital Cost	\$43.34
B/C Ratio	1.03
Net Present Value	\$1.15

### V.2 *Unquantified Benefits*

The benefits quantified in the analysis reflect only a portion of the expected value to society of completing the Archer Avenue and BRC Grade Separation Project. Examples of unquantified benefits include:

- Network-wide impacts on freight efficiency
- Reduced delays for trains operating in the GS9 corridor
- Air quality improvements for local residents in the project location with a population that has a high proportion of racial minorities
- Enhancements to pedestrian and bicyclist facilities
- Job creation and improvements in employment opportunities to three Tax Increment Finance (TIF) districts within the project corridor

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# APPENDIX A

## BCA Global Parameters

This BCA uses the following global parameters based on values provided by the USDOT and other sources.

### A-I. PASSENGER VALUE OF TIME

To estimate the benefits associated with travel time savings, a real Gross Domestic Product (GDP) growth rate is applied to USDOT-provided factors for Value of Time (VOT). 2019 VOT values are shown in Table A-1.

Table A-1: Value of Time Factor (2019 Dollars)

Trip Purpose / Vehicle Type	Value	Units
In-Vehicle Travel, All Purposes	\$17.90	<i>\$/person-hour</i>
Truck Drivers	\$30.80	<i>\$/person-hour</i>

Source: U.S. Department of Transportation, Benefit-Cost Analysis Guidance for Discretionary Grant Programs, February 2021 Table A-3: Value of Travel Time Savings. Accessed at <https://www.transportation.gov/sites/dot.gov/files/2021-02/Benefit%20Cost%20Analysis%20Guidance%202021.pdf>.

### A-II. AVERAGE VEHICLE OCCUPANCY

To convert the cost per passenger to cost per vehicle or vice versa, USDOT-provided factors for Average Vehicle Occupancy are used, as summarized in Table A-2. The vehicle occupancy for trucks is assumed to be one person.

Table A-2: Average Vehicle Occupancy Factor

Vehicle Type	Value	Units
Passenger Vehicles (All Travel)	1.67	<i>persons/automobile</i>
Truck	1.00	<i>persons/truck</i>

Source: U.S. Department of Transportation, Benefit-Cost Analysis Guidance for Discretionary Grant Programs, February 2021. Table A-4: Value of Travel Time Savings. Accessed at <https://www.transportation.gov/sites/dot.gov/files/2021-02/Benefit%20Cost%20Analysis%20Guidance%202021.pdf>.

### A-III. GDP GROWTH

To account for GDP growth during the analysis period, a GDP growth factor is applied to all costs as shown in Table A-3. Growth beyond the 10-year forecasts developed by the Congressional Budget Office was assumed to continue at the value of the final year of the forecast.

Table A-3: GDP Growth Factor (FY)

Factor	2019	2026	Units
Real GDP <sup>A</sup>	\$19,085.49	\$21,619.72	<i>billions of \$</i>
Growth Factor	1.00	1.13	

Source: A. U.S. Congressional Budget Office 10-year Economic Projections, February 2021. GDP. Accessed at <https://www.cbo.gov/about/products/budget-economic-data#4>

### A-IV. CRASH COSTS

To estimate the benefits of avoided crashes, USDOT-provided factors for Value of Reduced Fatalities and Injuries are used, as summarized in Table A-4.

Table A-4: BCA Value of Reduced Fatalities and Injuries (2019 dollars)

Factor	Value	Units
Fatality	\$10,900,000	<i>\$/person</i>
Injured (Unknown Severity)	\$197,600	<i>\$/person</i>
Unknown if Injured	\$150,200	<i>\$/person</i>
No Injury	\$3,700	<i>\$/person</i>
Possible Injury	\$72,500	<i>\$/person</i>
Non-incapacitating Injury	\$142,000	<i>\$/person</i>
Incapacitating Injury	\$521,300	<i>\$/person</i>
Property Damage	\$4,500	<i>\$/vehicle</i>

Source: U.S. Department of Transportation, Benefit Cost Analysis Guidance for Discretionary Grant Programs, Feb 2021. Tables A-1 and A-2 Accessed at <https://www.transportation.gov/sites/dot.gov/files/2021-02/Benefit%20Cost%20Analysis%20Guidance%202021.pdf>.

## A-V. FEMA COSTS

To estimate the emergency medical service benefits for the analysis, FEMA BCA Guidance (2011) projections are used. FEMA provides formulas to calculate the loss caused by first responder delays, including fire response, emergency medical service response, and hospital access as summarized in Table A-5, Table A-6, and Table A-7.

Table A-5: EMS-Related Formulas and Parameters

Parameter	Formula or Value	Units
Potential Cardiac Arrests	Population * 58.5 / 100,000	<i>cardiac arrests/year</i>
Average EMS Response Time		7 <i>minutes</i>
Survival Probability	$(1 + e^{-0.260 + 0.106 * (\text{Response Time} + 1) + 0.139 * (\text{Response Time} + 2)})^{-1}$	<i>percent</i>

Source: FEMA Benefit-Cost Analysis Re-engineering (BCAR). Page 17. Accessed at <https://files.hudexchange.info/course-content/ndrc-nofa-benefit-cost-analysis-data-resources-and-expert-tips-webinar/FEMA-BCAR-Resource.pdf>.

Table A-6: Fire-Related Formulas and Parameters

Parameter	Formula or Value	Units
Potential Fire Incidents	Population * 0.0055	<i>incidents/year</i>
Average Fire Response Time		5 <i>minutes</i>
Probability of No-Loss Incident	0.456 - 0.00264 * Response Time	<i>percent</i>
Average Property Dollar Loss	3845 + 431 * Response Time	<i>1993\$/incident</i>
Indirect Loss	0.1 * Property Dollar Loss	<i>\$/year</i>
Mortality and Injury Loss	3.3 * (Property Dollar Loss + Indirect Loss)	<i>\$/year</i>

Source: FEMA Benefit-Cost Analysis Re-engineering (BCAR). Page 13. Accessed at <https://files.hudexchange.info/course-content/ndrc-nofa-benefit-cost-analysis-data-resources-and-expert-tips-webinar/FEMA-BCAR-Resource.pdf>.

Table A-7: Hospital-Related Formulas and Parameters

Parameter	Formula or Value	Units
Potential Deaths due to AMI	Population * 50.9 / 100,000	<i>persons/year</i>
Potential Deaths due to Unintentional Injuries	Population * 39.7 / 100,000	<i>persons/year</i>
Increase in Deaths due to AMI	Potential Deaths * 0.0604 * Distance	<i>persons/year</i>
Increase in Deaths due to Unintentional Injuries	Potential Deaths * 0.0614 * Distance	<i>persons/year</i>

Source: FEMA Benefit-Cost Analysis Re-engineering (BCAR). Page 24. Accessed at <https://files.hudexchange.info/course-content/ndrc-nofa-benefit-cost-analysis-data-resources-and-expert-tips-webinar/FEMA-BCAR-Resource.pdf>.

## A-VI. EMISSIONS RATES

To estimate the emissions reduction benefits associated with reduced idling (5mph), emission rate factors derived from the California Air Resources Board Emissions FACTors (EMFAC) model are used for pollutants associated with mobile sources. Using the approach from the B/C Benefit-Cost Analysis model developed by the California Department of Transportation, emissions rates are aggregated for automobiles and trucks based on different vehicle fleet compositions to reflect the changing emissions profile as the fleet becomes greener over time. A growth rate was applied to estimate emissions rates for intermediate years. Fuel consumption factors from the EMFAC model are also used to derive an emissions rate based on fuel consumed, as summarized in Table A-8.

Table A-8: Emissions Rate Factors

Factor		2016	2036	Units	
<b>EMISSIONS RATES IN GRAMS PER MILE- 5 MPH</b>					
<b>Automobiles</b>					
a	Carbon Dioxide (CO <sub>2</sub> )	328.15	198.13	grams/mile	
b	Nitrogen Oxides (NO <sub>x</sub> )	0.1694	0.0365	grams/mile	
c	Particulate Matter (PM <sub>2.5</sub> )	0.0014	0.0007	grams/mile	
d	Sulfur Dioxide (SO <sub>2</sub> )	0.0033	0.002	grams/mile	
<b>Trucks</b>					
e	Carbon Dioxide (CO <sub>2</sub> )	1,197.87	1,142.66	grams/mile	
f	Nitrogen Oxides (NO <sub>x</sub> )	4.3131	0.3503	grams/mile	
g	Particulate Matter (PM <sub>2.5</sub> )	0.0654	0.004	grams/mile	
h	Sulfur Dioxide (SO <sub>2</sub> )	0.0115	0.0109	grams/mile	
<b>FUEL CONSUMPTION- 5 MPH</b>					
i	Automobiles	0.10240	0.05703	gallons/mile	
j	Trucks	0.21120	0.17100	gallons/mile	
<b>EMISSIONS RATES IN GRAMS PER GALLON- 5 MPH</b>					
<b>Automobiles</b>					
k	Carbon Dioxide (CO <sub>2</sub> )	a / i	11,847	12,888	grams/gallon
l	Nitrogen Oxides (NO <sub>x</sub> )	b / i	3.38	1.23	grams/gallon
m	Particulate Matter (PM <sub>2.5</sub> )	c / i	0.12	0.11	grams/gallon
n	Sulfur Dioxide (SO <sub>2</sub> )	d / i	0.12	0.13	grams/gallon
<b>Trucks</b>					
o	Carbon Dioxide (CO <sub>2</sub> )	e / j	21,363	40,539	grams/gallon
p	Nitrogen Oxides (NO <sub>x</sub> )	f / j	77.89	177.86	grams/gallon
q	Particulate Matter (PM <sub>2.5</sub> )	g / j	1.06	0.22	grams/gallon
r	Sulfur Dioxide (SO <sub>2</sub> )	h / j	0.20	0.35	grams/gallon

Source: California Department of Transportation Life-Cycle Benefit-Cost Analysis Model, Cal-B/C V6.2 Emissions Tables. Accessed at <https://dot.ca.gov/programs/transportation-planning/economics-data-management/transportation-economics>.

## A-VII. EMISSIONS COSTS

To estimate the benefits of avoided emissions, USDOT-provided factors for Emissions Cost are used, as summarized in Table A-9.

Table A-9: BCA Emissions Cost Factors (2019 dollars)

Year	Carbon Dioxide (CO <sub>2</sub> )	Nitrogen Oxides (NO <sub>x</sub> )	Particulate Matter (PM <sub>2.5</sub> )	Sulfur Dioxide (SO <sub>2</sub> )	Units
2020	\$50	\$15,700	\$729,300	\$40,400	\$/ short ton
2021	\$52	\$15,900	\$742,300	\$41,300	\$/ short ton
2022	\$53	\$16,100	\$755,500	\$42,100	\$/ short ton
2023	\$54	\$16,400	\$769,000	\$43,000	\$/ short ton
2024	\$55	\$16,600	\$782,700	\$43,900	\$/ short ton
2025	\$56	\$16,800	\$796,600	\$44,900	\$/ short ton
2026	\$57	\$17,000	\$807,500	\$45,500	\$/ short ton
2027	\$58	\$17,300	\$818,600	\$46,200	\$/ short ton
2028	\$59	\$17,500	\$829,800	\$46,900	\$/ short ton
2029	\$60	\$17,700	\$841,200	\$47,600	\$/ short ton
2030	\$61	\$18,000	\$852,700	\$48,200	\$/ short ton
2031	\$62	\$18,000	\$852,700	\$48,200	\$/ short ton
2032	\$63	\$18,000	\$852,700	\$48,200	\$/ short ton
2033	\$64	\$18,000	\$852,700	\$48,200	\$/ short ton
2034	\$66	\$18,000	\$852,700	\$48,200	\$/ short ton
2035	\$67	\$18,000	\$852,700	\$48,200	\$/ short ton
2036	\$68	\$18,000	\$852,700	\$48,200	\$/ short ton
2037	\$69	\$18,000	\$852,700	\$48,200	\$/ short ton
2038	\$70	\$18,000	\$852,700	\$48,200	\$/ short ton
2039	\$71	\$18,000	\$852,700	\$48,200	\$/ short ton
2040	\$72	\$18,000	\$852,700	\$48,200	\$/ short ton
2041	\$73	\$18,000	\$852,700	\$48,200	\$/ short ton
2042	\$75	\$18,000	\$852,700	\$48,200	\$/ short ton
2043	\$76	\$18,000	\$852,700	\$48,200	\$/ short ton
2044	\$77	\$18,000	\$852,700	\$48,200	\$/ short ton
2045	\$78	\$18,000	\$852,700	\$48,200	\$/ short ton

Year	Carbon Dioxide (CO <sub>2</sub> )	Nitrogen Oxides (NO <sub>x</sub> )	Particulate Matter (PM <sub>2.5</sub> )	Sulfur Dioxide (SO <sub>2</sub> )	Units
2046	\$79	\$18,000	\$852,700	\$48,200	<i>\$/ short ton</i>
2047	\$80	\$18,000	\$852,700	\$48,200	<i>\$/ short ton</i>
2048	\$81	\$18,000	\$852,700	\$48,200	<i>\$/ short ton</i>
2049	\$83	\$18,000	\$852,700	\$48,200	<i>\$/ short ton</i>
2050	\$84	\$18,000	\$852,700	\$48,200	<i>\$/ short ton</i>

Source: U.S. Department of Transportation, Benefit Cost Analysis Guidance for Discretionary Grant Programs, Feb 2021. Table A-6: Damage Costs for Emissions per metric ton. Accessed at <https://www.transportation.gov/sites/dot.gov/files/2021-02/Benefit%20Cost%20Analysis%20Guidance%202021.pdf>.

## A-VIII. FUEL COSTS

To estimate the benefits related to reduced fuel consumption, EIA annual fuel cost projections are used. Federal and state taxes are deducted from the total fuel cost since taxes constitute a transfer, rather than a benefit.

Table A-10: Fuel Cost (2019 dollars)

Fuel Type	2026 Value	Units
Gasoline	\$2.56	<i>\$/ person-hour</i>
Diesel	\$2.73	<i>\$/person-hour</i>

Source: EIA Annual projections to 2050. Table A12. Accessed at <https://www.eia.gov/analysis/projection-data.php#annualproj>.

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## APPENDIX B

# Detailed Benefit–Cost Analysis of Archer Avenue at BRC Grade Separation Project

**TABLE B-1: BCA SUMMARY**

Undiscounted Costs and Benefits										
Year	Calendar Year	Initial Construction Costs	Residual Value	Traffic Delay Cost Savings	Reduced Crash Exposure	Avoided First Responder Delay	Traffic Idling Cost Savings	Avoided Crossing Maintenance	Total Benefits	
-2	2017	\$294,662	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
-1	2018	\$392,883	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
0	2019	\$392,883	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
1	2020	\$392,883	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
2	2021	\$1,431,215	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
3	2022	\$5,331,978	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
4	2023	\$2,665,989	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
5	2024	\$32,740,214	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
6	2025	\$16,370,107	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
7	2026	\$0	\$0	\$1,049,918	\$1,044,845	\$2,136,483	\$33,249	\$15,728	\$4,280,222	
8	2027	\$0	\$0	\$1,085,927	\$1,048,994	\$2,168,612	\$33,802	\$15,980	\$4,353,316	
9	2028	\$0	\$0	\$1,123,514	\$1,053,174	\$2,201,221	\$34,208	\$16,242	\$4,428,359	
10	2029	\$0	\$0	\$1,161,393	\$1,057,385	\$2,234,316	\$35,112	\$16,494	\$4,504,700	
11	2030	\$0	\$0	\$1,201,054	\$1,061,628	\$2,267,904	\$35,612	\$16,756	\$4,582,954	
12	2031	\$0	\$0	\$1,242,416	\$1,065,902	\$2,301,992	\$36,609	\$17,028	\$4,663,946	
13	2032	\$0	\$0	\$1,285,201	\$1,070,208	\$2,336,589	\$36,945	\$17,304	\$4,746,247	
14	2033	\$0	\$0	\$1,329,460	\$1,074,547	\$2,371,700	\$37,483	\$17,584	\$4,830,774	
15	2034	\$0	\$0	\$1,375,244	\$1,078,918	\$2,407,335	\$38,003	\$17,869	\$4,917,369	
16	2035	\$0	\$0	\$1,422,604	\$1,083,323	\$2,443,499	\$38,445	\$18,159	\$5,006,030	
17	2036	\$0	\$0	\$1,471,596	\$1,087,762	\$2,480,202	\$38,900	\$18,453	\$5,096,913	
18	2037	\$0	\$0	\$1,522,274	\$1,092,234	\$2,517,451	\$39,443	\$18,752	\$5,190,154	
19	2038	\$0	\$0	\$1,574,699	\$1,096,741	\$2,555,254	\$40,079	\$19,056	\$5,285,829	
20	2039	\$0	\$0	\$1,628,928	\$1,101,283	\$2,593,619	\$40,404	\$19,365	\$5,383,598	
21	2040	\$0	\$0	\$1,685,025	\$1,105,861	\$2,632,554	\$40,984	\$19,678	\$5,484,103	
22	2041	\$0	\$0	\$1,712,331	\$1,105,861	\$2,632,554	\$40,866	\$19,997	\$5,511,609	
23	2042	\$0	\$0	\$1,740,078	\$1,105,861	\$2,632,554	\$40,775	\$20,321	\$5,539,590	
24	2043	\$0	\$0	\$1,768,276	\$1,105,861	\$2,632,554	\$40,590	\$20,651	\$5,567,931	
25	2044	\$0	\$0	\$1,796,930	\$1,105,861	\$2,632,554	\$40,576	\$20,985	\$5,596,905	
26	2045	\$0	\$0	\$1,826,048	\$1,105,861	\$2,632,554	\$40,398	\$21,325	\$5,626,187	
27	2046	\$0	\$0	\$1,855,639	\$1,105,861	\$2,632,554	\$40,172	\$21,671	\$5,655,897	
28	2047	\$0	\$0	\$1,885,709	\$1,105,861	\$2,632,554	\$40,082	\$22,022	\$5,686,227	
29	2048	\$0	\$0	\$1,916,266	\$1,105,861	\$2,632,554	\$39,963	\$22,379	\$5,717,022	
30	2049	\$0	\$0	\$1,947,318	\$1,105,861	\$2,632,554	\$39,857	\$22,741	\$5,748,332	
31	2050	\$0	\$0	\$1,978,874	\$1,105,861	\$2,632,554	\$39,885	\$23,110	\$5,780,283	
32	2051	\$0	\$0	\$2,010,941	\$1,105,861	\$2,632,554	\$39,837	\$23,484	\$5,812,677	
33	2052	\$0	\$0	\$2,043,527	\$1,105,861	\$2,632,554	\$39,836	\$23,865	\$5,845,643	
34	2053	\$0	\$0	\$2,076,642	\$1,105,861	\$2,632,554	\$40,059	\$24,252	\$5,879,367	
35	2054	\$0	\$0	\$2,110,293	\$1,105,861	\$2,632,554	\$40,306	\$24,645	\$5,913,658	
36	2055	\$0	\$0	\$2,144,489	\$1,105,861	\$2,632,554	\$40,576	\$25,044	\$5,948,525	
37	2056	\$0	\$36,007,687	\$0	\$0	\$0	\$0	\$0	\$0	
<b>Total</b>		<b>\$60,012,811</b>	<b>\$36,007,687</b>	<b>\$48,972,613</b>	<b>\$32,710,717</b>	<b>\$75,137,042</b>	<b>\$1,163,055</b>	<b>\$600,939</b>	<b>\$158,584,367</b>	

**TABLE B-1: CONTINUED**

Discounted Costs and Benefits										
Year	7% Discount Factor	Capital Costs	Residual Value	Traffic Delay Cost Savings	Reduced Crash Exposure	Avoided First Responder Delay	Traffic Idling Cost Savings *	Avoided Crossing Maintenance	Total Benefits *	
-2	1.000	\$294,662	\$0	0	0	0	0	\$0	\$0	\$0
-1	1.000	\$392,883	\$0	0	0	0	0	\$0	\$0	\$0
0	1.000	\$392,883	\$0	0	0	0	\$0	\$0	\$0	\$0
1	0.935	\$367,180	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
2	0.873	\$1,250,079	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
3	0.816	\$4,352,482	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
4	0.763	\$2,033,870	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
5	0.713	\$23,343,320	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
6	0.666	\$10,908,093	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
7	0.623	\$0	\$0	\$653,836	\$650,677	\$1,330,494	\$28,549	\$9,794	\$2,673,351	\$2,673,351
8	0.582	\$0	\$0	\$632,019	\$610,524	\$1,262,152	\$27,546	\$9,301	\$2,541,543	\$2,541,543
9	0.544	\$0	\$0	\$611,117	\$572,857	\$1,197,318	\$26,511	\$8,835	\$2,416,639	\$2,416,639
10	0.508	\$0	\$0	\$590,393	\$537,521	\$1,135,813	\$25,788	\$8,385	\$2,297,899	\$2,297,899
11	0.475	\$0	\$0	\$570,612	\$504,372	\$1,077,465	\$24,893	\$7,961	\$2,185,303	\$2,185,303
12	0.444	\$0	\$0	\$551,647	\$473,273	\$1,022,112	\$24,267	\$7,561	\$2,078,860	\$2,078,860
13	0.415	\$0	\$0	\$533,313	\$444,098	\$969,601	\$23,384	\$7,180	\$1,977,577	\$1,977,577
14	0.388	\$0	\$0	\$515,588	\$416,728	\$919,786	\$22,633	\$6,819	\$1,881,554	\$1,881,554
15	0.362	\$0	\$0	\$498,452	\$391,050	\$872,529	\$22,041	\$6,477	\$1,790,548	\$1,790,548
16	0.339	\$0	\$0	\$481,885	\$366,959	\$827,698	\$21,337	\$6,151	\$1,704,030	\$1,704,030
17	0.317	\$0	\$0	\$465,870	\$344,357	\$785,169	\$20,679	\$5,842	\$1,621,916	\$1,621,916
18	0.296	\$0	\$0	\$450,386	\$323,153	\$744,823	\$20,086	\$5,548	\$1,543,996	\$1,543,996
19	0.277	\$0	\$0	\$435,417	\$303,258	\$706,549	\$19,555	\$5,269	\$1,470,048	\$1,470,048
20	0.258	\$0	\$0	\$420,946	\$284,593	\$670,240	\$18,972	\$5,004	\$1,399,755	\$1,399,755
21	0.242	\$0	\$0	\$406,956	\$267,080	\$635,796	\$18,491	\$4,753	\$1,333,075	\$1,333,075
22	0.226	\$0	\$0	\$386,496	\$249,607	\$594,202	\$17,728	\$4,514	\$1,252,547	\$1,252,547
23	0.211	\$0	\$0	\$367,064	\$233,278	\$555,329	\$17,134	\$4,287	\$1,177,092	\$1,177,092
24	0.197	\$0	\$0	\$348,610	\$218,017	\$518,999	\$16,451	\$4,071	\$1,106,148	\$1,106,148
25	0.184	\$0	\$0	\$331,083	\$203,754	\$485,046	\$15,844	\$3,867	\$1,039,593	\$1,039,593
26	0.172	\$0	\$0	\$314,437	\$190,424	\$453,314	\$15,247	\$3,672	\$977,094	\$977,094
27	0.161	\$0	\$0	\$298,629	\$177,967	\$423,658	\$14,681	\$3,487	\$918,421	\$918,421
28	0.150	\$0	\$0	\$283,615	\$166,324	\$395,942	\$14,172	\$3,312	\$863,365	\$863,365
29	0.141	\$0	\$0	\$269,356	\$155,443	\$370,039	\$13,693	\$3,146	\$811,676	\$811,676
30	0.131	\$0	\$0	\$255,814	\$145,274	\$345,831	\$13,343	\$2,987	\$763,249	\$763,249
31	0.123	\$0	\$0	\$242,952	\$135,770	\$323,207	\$12,939	\$2,837	\$717,705	\$717,705
32	0.115	\$0	\$0	\$230,738	\$126,888	\$302,062	\$12,457	\$2,695	\$674,839	\$674,839
33	0.107	\$0	\$0	\$219,137	\$118,587	\$282,301	\$12,007	\$2,559	\$634,591	\$634,591
34	0.100	\$0	\$0	\$208,120	\$110,829	\$263,833	\$11,606	\$2,430	\$596,817	\$596,817
35	0.094	\$0	\$0	\$197,656	\$103,578	\$246,573	\$11,227	\$2,308	\$561,343	\$561,343
36	0.088	\$0	\$0	\$187,719	\$96,802	\$230,442	\$10,870	\$2,192	\$528,025	\$528,025
37	0.082	\$0	\$2,945,747	\$0	\$0	\$0	\$0	\$0	\$0	\$0
<b>Total</b>		<b>\$43,335,451</b>	<b>\$2,945,747</b>	<b>\$11,959,861</b>	<b>\$8,923,040</b>	<b>\$19,948,324</b>	<b>\$554,131</b>	<b>\$153,243</b>	<b>\$41,538,599</b>	

\* Includes carbon-related benefits discounted at 3%

Discounted Benefit Summary	
<b>Benefit Cost Ratio</b>	<b>1.03</b>
<b>Net Present Value</b>	<b>\$1,148,895</b>

