APPENDIX B

Benefit-Cost Analysis

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1.0 Introduction

This technical memorandum documents the benefit-cost analysis (BCA) developed in support of the BUILD Discretionary Grant application for the **Memphis Innovation Corridor**. The main component of the Memphis Innovation Corridor project is a new 8.25-mile bus rapid transit (BRT) line between the William Hudson Transit Center, which is the Memphis Area Transit Authority's (MATA) main hub and the University of Memphis. The BRT will operate on dedicated bus lanes over a two-mile segment of the route in Downtown Memphis. A three-mile segment of the route through midtown Memphis will be converted from a six-lane undivided roadway to a divided five lane section. There are also safety improvements at key segments of the route that currently experience higher crash rates than similar facilities in the region. A detailed description of the project is provided in the grant application.

The original BCA was conducted by HDR, Inc. as part of MATA's Midtown Area Connector project in 2017. This analysis and report have been updated based on an improved project scope associated with a change in laneage on the route to provide for exclusive bus lanes on segments of roadway in downtown, change in laneage along Union Avenue, and safety improvements along the corridor.

Section 2 of this report documents the methodological framework used in the BCA. **Section 3** provides an overview of the project, including the no-build and build discussions. **Section 4** discusses the inputs used in the estimation of project costs and benefits. **Section 5** provides estimates of travel demand and traffic growth. Specific data elements and assumptions pertaining to the long-term outcome selection criteria are presented in **Section 6**, along with the associated benefit estimates. Estimates of the project's Net Present Value (NPV), its Benefit-Cost ratio (BCR) and other project evaluation metrics are reported in **Section 7**. **Section 8** provides the outcomes of the sensitivity analysis. Additional data tables are provided in **Section 9**, which includes annual estimates of benefits and costs, as well as intermediate values to assist in review of the application.

2.0 Methodology

The Benefit-Cost Analysis (BCA) conducted for this project includes the monetized benefits and costs measured using the *Benefit-Cost Analysis Guidance for Discretionary Grant Programs*, USDOT, December 2019, as well as the quantitative and qualitative merits of the project. A BCA provides estimates of the anticipated benefits that are expected to accrue from a project over a specified period and compares them to the anticipated costs of the project. Costs include both the resources required to develop the project and the costs of maintaining the new or improved asset over time. Estimated benefits are based on the projected impacts of the project on both users and non-users of the facility, valued in monetary terms.

The BCA provides a useful benchmark from which to evaluate and compare potential transportation investments. The specific methodology developed for this application was developed using the BCA guidance developed by USDOT and is consistent with the discretionary grant program guidelines. In particular, the methodology involves:

- Establishing existing and future conditions under the build and no-build scenarios, (and considering an alternative to the Full Build);
- Assessing benefits with respect to each of the five long-term outcomes identified in the Notice of Funding Opportunity;
- Measuring benefits in dollar terms, whenever possible, and expressing benefits and costs in a common unit of measurement;
- Using DOT guidance for the valuation of travel time savings, safety benefits and reductions in air emissions, while relying on industry best practice for the valuation of other effects;
- Discounting future benefits and costs with the real discount rates recommended by the DOT; and
- Conducting a sensitivity analysis to assess the impacts of changes in key estimating assumptions.

3.0 Project Overview

The requested BUILD funds will be used to support the Memphis Innovation Corridor, a Bus Rapid Transit (BRT) service linking Downtown, Midtown, the Medical District, and the University of Memphis along Union and Poplar Avenues, with additional roadway and ADA accessibility improvements. The proposed investment will tie investments in north-south bicycle, pedestrian, and transit improvements to connect historically disinvested communities to key centers of opportunity in the City, including Downtown and Medical District employment, services, and education such as the University of Memphis. The outcome of the project will build on the success of other projects in the region, such as the "Main Street to Main Street" TIGER-funded project, and many new private development projects along the corridor.

3.1 Base Case and Alternatives

Estimates of baseline conditions were forecasted over the analysis period and then compared to alternative conditions based on the build scenario.

Base Case – No-Build Alternative

The Union-Poplar corridor carries more than 25,000 daily automobile trips and is consistently at capacity during rush hour. Auto trips in the corridor are expected to grow over the next 40 years, but the corridor is constrained and expansion is not a feasible option. There is a high crash rate along the undivided six-lane section of Union Avenue and left turn movement restrictions at key intersections.

The area encompasses the greater downtown area and key regional activity centers such as the Medical District, University of Memphis, Rhodes College, Christian Brothers University, Museums, Liberty Bowl Stadium, AutoZone Park, Overton Square/Park, Cooper-Young and a host of shopping centers, restaurants and retails. Beyond economic growth, transit can help the downtown and the surrounding neighborhoods flourish by giving citizens an alternative to being dependent on automobiles.

Build Alternative – Memphis Innovation Corridor

To more efficiently access Midtown Memphis, a BRT alignment is proposed. The Memphis Innovation Corridor is needed to help Memphis achieve the goals of the Transit Vision Plan established are part of the City of Memphis 3.0 Comprehensive Plan, the Mid-Town Alternatives Analysis, and the 2012 Short Range Transit Plan. This key corridor route will create a framework for future development of BRT on highest ridership corridors." The Memphis Innovation Corridor will support this vision by enhancing economic competitiveness and providing more mobility options in the urban core.

The City has considered alternatives to address the safety and congestion issues. An Alternatives Report, published in 2016, documents the analysis for over seven options. This BCA documents the results of the locally preferred alternative (LPA). The project also incorporates a plan to reduce the laneage on Union Avenue to allow for construction of a five-lane section with a two-way left-turn lane with access management improvements.

3.2 Impacted and Affected Population

The BCA measured impacts on users of the corridor (drivers), BRT riders, public agencies (service providers), and external impacts on the local and national population. **Table 1** summarizes the impacted and affected populations

Table 1 - Impacted and Affected Populations

Affected Population	Potential Impact
Bus Riders	Reduced travel time on bus routes using BRT
Service Provider	MATA will receive an increase in operating revenue
General Population	Improved transportation options and reduced emissions due to reduction in VMT along the corridor
Drivers	Reduced number of crashes, reduced travel time, increased travel time reliability
Station Area Communities for users and non-users of BRT	Increase in property values and opportunities for employment
Ladder of Opportunity	22% of the population is low income and 46% is minority in the area. The project will create safer, more efficient access to jobs and services along the corridor to which there may currently be limited access for vulnerable populations.

3.3 Project Cost and Schedule

The BCA results are presented in 2018 Dollars using the Bureau of Labor Statistics Consumer Price Index (CPI) for December of 2018 to make the conversion to this base year. The project costs are also expressed in Dollars of 2018. The total capital cost of the project is estimated to be $73.8 million.

In addition to cost estimates for capital expenditures, the analysis includes estimates of the net new operations and maintenance costs likely to result from implementation of the project. Costs considered include maintenance of structures and the labor cost of operations, as well as routine resurfacing and maintenance. Total annual transit ramp O&M cost amounts to $3.6 million.

In addition to cost estimates, a schedule of planning, construction and implementation was developed. Preliminary engineering began in 2019 and construction would begin in 2021 and conclude during 2025. The main benefit categories associated with the project are mapped into the five, long-term outcome criteria established by the USDOT, as shown in **Table 2.**

Table 2 - Expected Effects on Long-Term Outcomes and Benefit Categories

Long-Term Outcomes	Benefit or Impact Categories	Description	Monetized	Quantified	Qualitative
State of Good Repair	Pavement Maintenance Cost Savings	Reductions in pavement maintenance costs due to changes in roadway usage	X	X	
Economic Competitiveness	Travel Time Savings	Travel time savings from reduced congestion	X	X	
	Vehicle Operating Cost Savings	Reduction in out-of-pocket costs to drivers switching to transit	X		
Quality of Life	Transit-oriented development	Increases in property value due to improved access and amenities near station areas	X		X
	Low Income Mobility*	Portion of travel time savings accruing to low income users	X		X
Environmental Sustainability	Emissions Cost Savings	Reductions in greenhouse gas and air pollutant emissions due to changes in auto use	X	X	
Safety	Crash reduction	Crash reduction due to changes in roadway laneage and geometry	X	X	

* Low income mobility benefits are not added to the BCA, they are a subset of travel time savings benefits.

4.0 General Assumptions

The BCA measures benefits against costs throughout a period of analysis beginning at the start of the 4-year design and construction period for BRT and including 30 years of operations, for a total of 34 years of analysis. The methodology makes several important assumptions and seeks to avoid overestimation of benefits and underestimation of costs. The assumptions include:

- Input prices are expressed in 2018 Dollars;
- The period of analysis begins in 2019 and ends in 2054. It includes project development and construction years (2021 - 2025) and 30 years of operations (2025 - 2054);
- A 7 percent real discount rate is assumed throughout the period of analysis. A 3 percent real discount rate is used for sensitivity analysis;
- Opening year crash reduction and transit demand are inputs to the BCA and are assumed to be fully realized in the opening year (no ramp-up); and
- The results shown in this document correspond to the effects of the Full Build alternative.

5.0 Demand

The initial level of and growth in vehicle traffic and transit ridership were analyzed for the no-build and build alternatives.

5.1 Assumptions

Assumptions were made in order to estimate the demand for BRT and the impact of the project on the roadway network, in terms of vehicle miles traveled (VMT) and vehicle hours traveled (VHT). Key assumptions are summarized in **Table 3**.

Table 3 - Assumptions Used in the Estimation of Demand

Variable Name	Unit	Value	Source
Diversion from Local Bus Service	%	83.3%	STOPS Model, MATA, and City of Memphis
Diversion from Automobiles	%	16.7%	
Induced Demand	%	0%	
BRT Ridership Growth Rate	%	1.3%	
Passenger Vehicle Occupancy Rate	Person per Vehicle	1.35	USDOT BCA Guidance, June 2018
BRT Average Speed	Mile per Hour	25	Synchro Model Results, MATA, and City of Memphis
Local Bus Average Speed	Mile per Hour	20	
Bus Trip Length	Miles	8.3	MATA and City of Memphis
Annual Average Daily Traffic, 2025	Each	27,529	Memphis MPO Travel Demand Model, MATA, and City of Memphis
Auto Trip Length	Miles	8.3	
Automobile Average Speed, 2024	Mile per Hour	20	
Automobile Average Speed, 2025	Mile per Hour	22	

5.2 Demand Projections

As shown in **Table 4**, BRT ridership is expected to increase at an average annual growth of 1.3 percent throughout the lifecycle of the project. Table 4 also presents the reduction in daily VMT in the corridor due to the reduction in laneage on North Second Street and BB King Boulevard for the bus only lanes, a change in the cross section of Union Avenue from six lanes to five lanes, and diversion of auto riders to the BRT in the opening year and subsequent years.

Table 4 - Demand Projections

	2025	2034	2044	2054
BRT Ridership	4,449	4,997	5,686	6,470
Diverted from Bus	3,708	4,165	4,739	5,392
Reduction in VMT	10,453	20,173	35,047	51,161

6.0 Benefits Measurement, Data and Assumptions

The measurement approach used for each long-term outcome and benefit category is provided in this section with an overview of the associated methodology, assumptions, and estimates.

6.1 State of Good Repair

To quantify the benefits associated with maintaining the existing transportation network in a state of good repair, the impacts on the life-cycle pavement maintenance costs, as well as the residual value of the project at the end of the analysis period (2054), were estimated per US DOT guidance.

6.1.1 Methodology

Pavement maintenance cost savings are a function of the estimated reduction in VMT and are calculated as the difference between pavement maintenance costs in the no-build and the build scenarios.

The residual value of the project implies that infrastructure investments in the corridor will have significant value beyond the 30-year operation period within the BCA. It is estimated using a straight-line depreciation method and assuming no salvage value at the end of the project/building's useful life (30 years).

6.1.2 Assumptions

The assumptions used in the estimation of State of Good Repair benefits are summarized in **Table 5**. The estimates of rerouting mileage savings were developed by Valley Metro based on the proposed rerouting plan.

Table 5 - Assumptions used to Estimate of Transit O&M Savings and Residual Value Benefits

Variable Name	Unit	Value	Source
Pavement Maintenance Cost	$ per VMT	$0.0015	US DOT, Addendum to the 1997 Federal Highway Cost Allocation Study Final Report, May 2000 (original estimate was inflated to $2017)
Useful Life of Asset	Year	30	Assumption

6.1.3 Benefit Estimates

The undiscounted pavement maintenance cost savings are estimated at $4,004 in the opening year and $363,964 over the analysis period. Results by calendar year of operation are shown in Section 9. Using a 7 percent discount rate, the lifecycle benefits from pavement maintenance cost savings amount to $83,068. The project's residual value at the end of the analysis period is estimated at $0, since it is assumed that the project useful life is 30 years.

Table 6 - Estimates of State-of-Good-Repair Benefits, in 2018 Dollars

	In Project Opening Year (2025)	Over the Project Lifecycle	
		In Constant Dollars	Discounted at 7 %
Pavement Maintenance Cost Savings	$4,004	$363,964	$83,068
Residual Value	N/A	$0	$0

6.2 Economic Competitiveness

The project will contribute to enhancing the economic competitiveness through improvements in the mobility of people and goods within and across the study area. In this analysis, two measures of mobility are presented: travel-time savings and out-of-pocket transportation cost savings.

6.2.1 Methodology

The framework used in the estimation of user benefits is based upon the theory of demand and involves the estimation of changes in consumer surplus.

The demand for travel is an inverse relationship between the number of trips "demanded" and the generalized cost of travel, which includes both travel time and out-of-pocket costs (such as vehicle operating and parking costs for auto users, or fare payments for transit riders). That relationship is depicted in **Figure 1**. The term "consumer surplus" refers to the area between the demand curve and the actual cost of travel at any point in time. It is a measure of welfare to the extent that people who are traveling at that cost are "paying" less than what they would be willing to pay; in other words, the value they are placing on a trip (as measured by their willingness-to-pay along the demand curve) is higher than what is being paid.

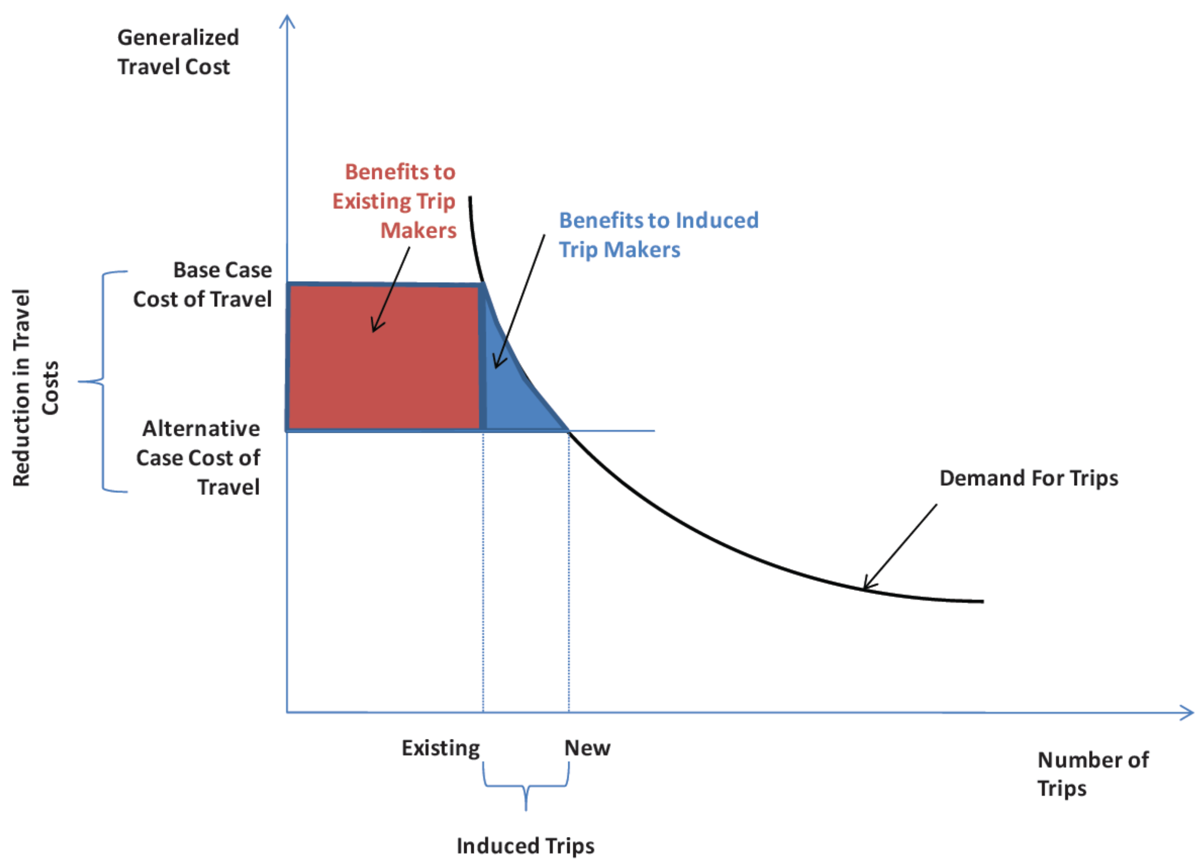

Figure 1 - Framework for the Estimation of User Benefits

Source: Midtown Area Connector Benefit Cost Analysis, HDR, Inc.

The project will reduce the general cost of travel and result in benefits to both existing and new trip-makers. Benefits to existing trip-makers are represented by the red rectangle in Figure 1. They are estimated as the difference between the generalized cost of travel in the base case and the generalized cost of travel in the build scenario times the number of existing trips.

In addition, as the generalized cost of travel is being reduced, additional trips (beyond those diverted from other modes) are expected. These induced trip-makers represent a portion of all potential trip-makers who did not make a trip (or as many trips) in the no-build scenario but are now “attracted” to the lower generalized cost allowed by the investment.

User benefits resulting from new trips are depicted by the blue triangle in. They are estimated using the “rule-of-a-half.” Note that the change in generalized cost from no-build to build conditions only represents the change in user costs (travel time plus out-of-pocket costs). Social costs, including air emissions, accident occurrences and congestion externalities are assumed not to affect trip making or modal decisions in this analysis. The elasticity of demand (the slope of the demand curve) is estimated, based on existing knowledge about travel costs in the corridor and ridership forecasts developed for the project.

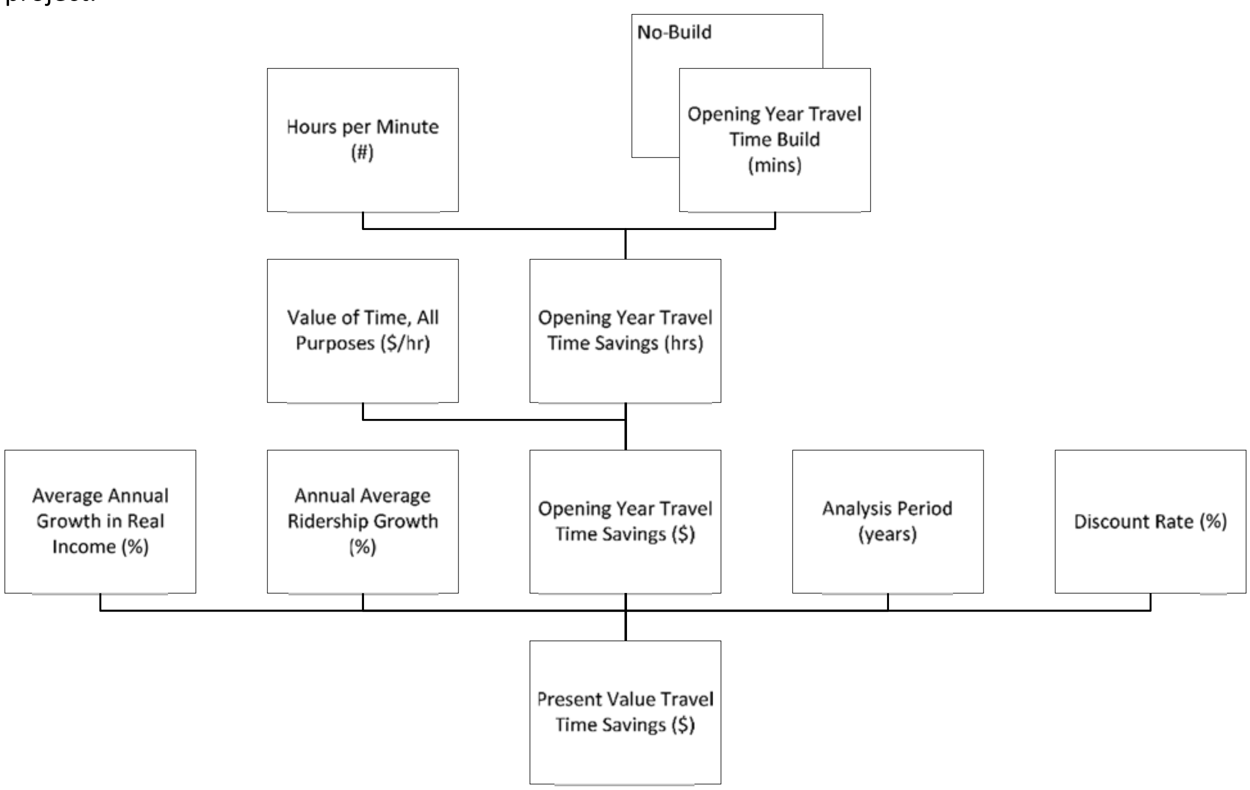

Figure 2 - Structure and Logic Diagram - Travel Time Savings
Source: Midtown Area Connector Benefit Cost Analysis, HDR, Inc.

Generalized travel cost has two components: travel time cost and out-of-pocket transportation costs. Travel time savings for travelers are dependent on their value of time (VOT) and the reduction of time spent on traveling (travel time).

Once the project is complete, some car drivers will experience a reduction in travel time as a result of less congestion. Travelers who divert from autos to buses might also experience a reduction in travel time depending on their origin and destination. VOT is then applied to each reduction in travel time to estimate the reduction in travel time costs.

Out-of-pocket costs are composed of four vehicle operating costs: fuel, oil, tires, maintenance and depreciation. The consumption rates for these costs are derived from average vehicle speed and combined with unit cost estimates to derive total out-of-pocket costs per mile and per trip. The out-of-pocket costs are combined with parking cost to estimate the total out-of-pocket cost per trip for auto users. The decrease in out-of-pocket costs in the build scenario represents out- of-pocket cost savings for remaining auto users. For travelers who divert from auto to buses, the out-of-pocket savings are estimated by subtracting fare payments from out-of-pocket costs.

6.2.2 Assumptions

The assumptions used in the estimation of transit travel time savings are summarized in the table below.

Table 7 - Assumptions used in the Estimation of Travel Time Savings

Variable Name	Unit	Value	Source
Travel Time Cost – Personal Travel	$ per Hour	$14.20	US DOT, Benefit-Cost Analysis Guidance for Discretionary Grant Programs, June 2018
Travel Time Cost – Business Travel	$ per Hour	$26.50	
Weighted Average Travel Time Cost	$ per Hour	$14.80	
Real Annual Growth Rate of Value of Time	%	0%	Assumption

Out-of-pocket costs are calculated using consumption rates for fuel, oil, tires, maintenance and depreciation from the Highway Economic Requirements System – State Version (HERS-ST) and unit costs from US DOT. The table below lists these unit costs along with the average transit fares per trip.

Table 8 - Assumptions used in the Estimation of Travel Time Savings

Variable Name	Unit	Value	Source
Vehicle Operating Costs – Fuel*	$ per Gallon	Varies*	Energy Information Administration, Annual Energy Outlook 2017 (April 2017)
Vehicle Operating Costs – Oil	$ per Quart	$9.96	US DOT, FHWA HERS-ST
Vehicle Operating Costs – Tires	$ per Tire	$89.50	
Vehicle Operating Costs - Maintenance	$ per 1,000 Miles	$173.00	
Vehicle Operating Costs – Depreciation	$ per Vehicle	$21,669	
BRT Fare	$ per Trip	$1.75	MATA
Bus Fare	$ per Trip	$1.75	

* The real cost of fuel varies over time (based on projections from the Energy Information Administration's Annual Energy Outlook 2017).

6.2.3 Benefit Estimates

The tables below present our estimates of travel time savings afforded by the proposed project.

Table 9 - Estimates of Economic Competitiveness Benefits, in 2018 Dollars

	In Project Opening Year	Over the Project Lifecycle	
		In Constant Dollars	Discounted at 7 %
Travel Time Cost Savings	-$408,757	-$37,727,868	-$8,578,044
Out-of-Pocket Savings	$3,305,120	$122,391,943	$33,730,175
Total	$2,896,363	$84,664,075	$25,152,130

6.3 Quality of Life

Community cohesiveness stems from individuals' mobility and goods and services' accessibility being enhanced via transit-oriented development. In this BCA, two types of livability improvements are presented: community development and low-income mobility.

6.3.1 Methodology

Economic development of the community and appreciation of land and building values to nearby properties are associated with the amenity effect of the transit line. This induced property value appreciation is often referred to as transit premium.

For a new property near the transit alignment, its market price or rental rate at the time of purchase or lease is assumed to capture the expected lifecycle stream of benefits. The amount of transit premium is then realized by the property owner or lessee annually at an increasing rate to reflect growing certainty over time. As a result of these two assumptions, the transit premium rate (as a percentage of property value) is applied once to the price of new property only, and the dollar amount of benefits is spread over the analysis horizon, subject to time discounting.

There are five key components in estimating transit premium: property number and growth rate, property value and growth rate, and transit premium rate. The first four are derived through historic, current, and forecast (or planned) land use and property data of the impact area. These estimates are assumed to remain unchanged with or without transit. The last component, the transit premium rate, is estimated based on the property value impact study by Perk and Catalá (2009).

Property prices are multiplied by the transit premium rates to compute lifetime amount of value appreciation due to the project. For any property, it will take 30 years for all premiums to be realized, independent of this BCA's horizon. The rate at which the premium amount is realized over time is computed as shown in Table 10. The first ten years of service are assumed to be a ramp-up period and the ramp-up parameters (a and b) are chosen for formulation continuity.

Table 10 - Economic Development Estimation

Time Horizon	Formulation
First Ten Years	a * Property Price* Transit Premium Rate / b + (1-a) Property Price* Transit Premium Rate / b *(Years of Service+1)/ (Years of Gradual Realization+1)
Rest of Realization Years (=20)	Property Price* Transit Premium Rate / b
Parameters: a=0.3, b=26.5	

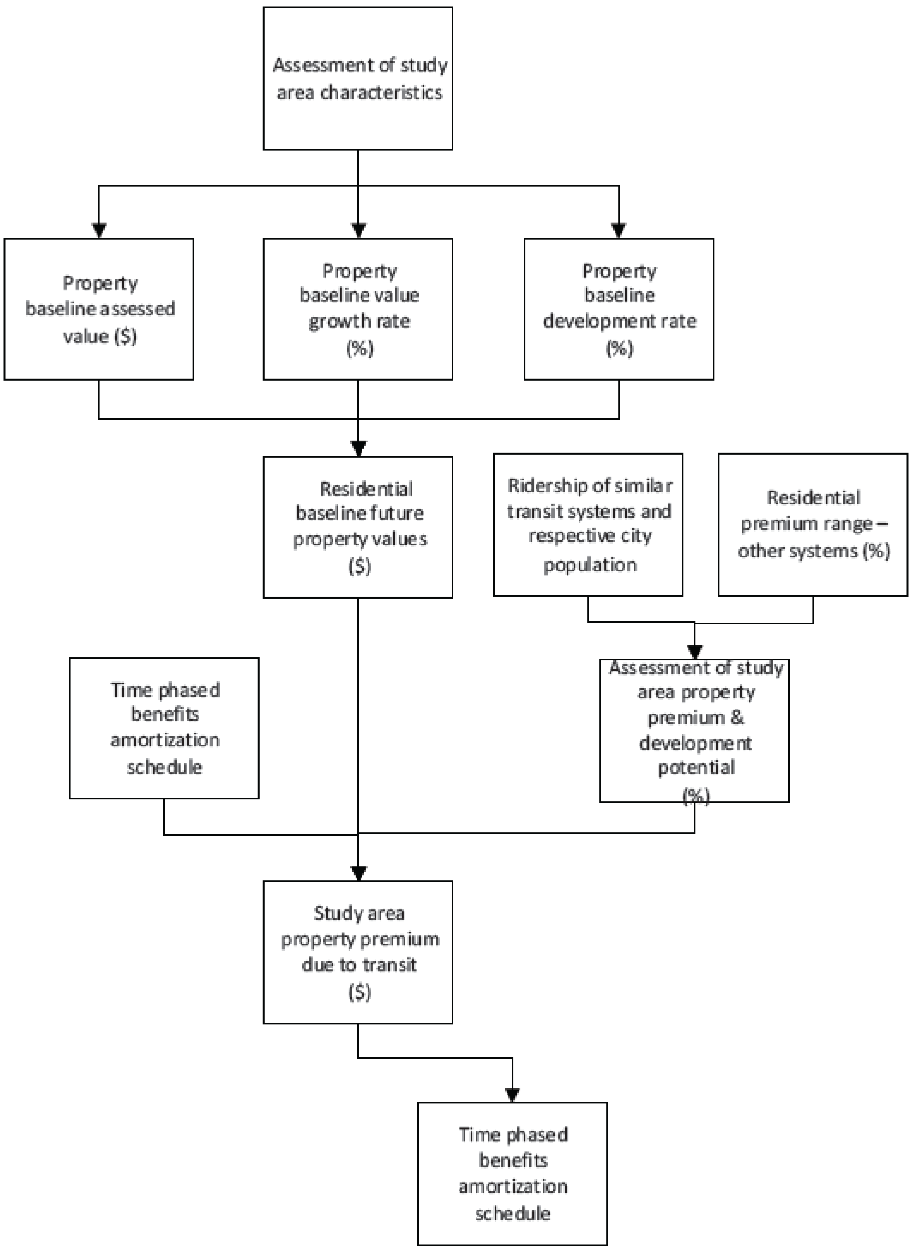

Figure 3 - Structure and Logic Diagram - TOD Benefits

Source: Midtown Area Connector Benefit Cost Analysis, HDR, Inc.

6.3.2 Assumptions

The 2016 baseline property data obtained for the City of Memphis mapped to the study area using a 0.5-mile buffer from the alignment using ERSI ArcGIS Online. According to ESRI Community Analyst, there are 20,745 residential parcels, with a median value of $239,085. ESRI also provides the forecast value of 2022 at $287,338, which produces an annual growth rate of 3.7 percent.

Additionally, there are 3,422 vacant parcels. Assuming theses parcels will be absorbed by 2022, the parcel construction rate is 3.1 percent a year.

For the transit premium, which measures a one-time increase in property value to be capitalized over 30 years, Perk and Catalá (2009) reports an estimate of 0.05 percent.

6.3.3 Benefits Estimates

Over the study horizon, there will be $3.3 million in TOD benefits associated with the BRT project. The amount is smaller than the congestion management user benefits, therefore there are no TOD benefits that are above and beyond the estimated user benefits. To avoid double counting, the TOD benefits estimated here are not added to the BCA.

In terms of equity improvements, the BCA attribute 22% of the $22.0 million of Economic Competitiveness benefits (discounted) to populations with low income. This amounts to $4.8 million and it represents the overall gain in competitiveness and potential monetized income/ productivity increase. Similarly, the benefits to minority populations amount to $10.1 million as 46% of the impacted populations are minority. These equity improvement benefits are duplicative to the BCA and are therefore not included in the quantitative evaluation; they are reported here to demonstrate the benefits to the minority and disadvantaged communities.

6.4 Environmental Sustainability

The project will contribute to environmental sustainability in the project corridor through reduced demand on the roadway due to the change in capacity and reduced usage of motorized vehicles. This and the use of electric buses will result in lowered emissions.

In the BCA, only the benefits from reduced emissions are monetized. Two categories of environmental impacts are considered for this project: reductions in carbon emissions and reductions in non-carbon emissions. Non-carbon emissions include volatile organic compounds (VOC), nitrogen oxides (NOx), sulfur dioxide (SO2) and fine particulate matter (PM2.5).

6.4.1 Methodology

Reductions in emission volumes are derived based upon the reduction in VMT resulting from diversion to public transit and the improved travel times due to the proposed signal coordination. Emission rates for Shelby County were obtained from Motor Vehicle Emission Simulator (MOVES) – a tool provided by the U.S. Environmental Protection Agency (EPA). Per-unit emission costs are applied to the emission reduction volumes due to the reduction in VMT caused by modal shifts.

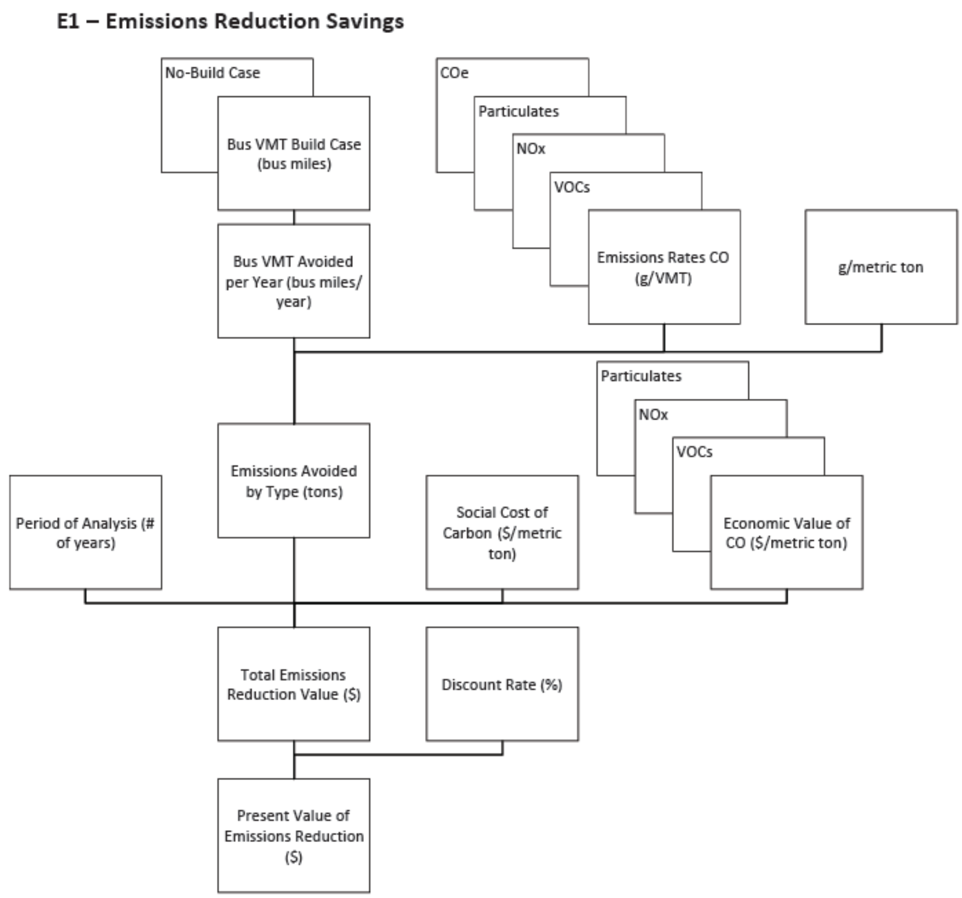

Figure 4 - Structure and Logic Diagram - Environmental Benefits
Source: Midtown Area Connector Benefit Cost Analysis, HDR, Inc.

6.4.2 Assumptions

The assumptions used in the estimation of environmental sustainability benefits are summarized in Table 11.

Table 11 - Assumptions used in the Estimation of Emissions Reductions Benefits

Emissions Type	Unit	Value	Source
Carbon Dioxide (CO_2)	$ per Short Ton	-	US DOT, Benefit-Cost Analysis Guidance for Discretionary Grant Programs, June 2018
Volatile Organic Compounds (VOC)		$2,000	
Nitrogen Oxides (NOX)		$8,300	
Particulate Matter (PM2.5)		$377,800	
Sulfur Dioxide (SO_2)		$48,900	

6.4.3 Benefit Estimates

The reduction in VMT along the project corridor from reduced capacity and a shift from auto to bus will result in a significant reduction in vehicle emissions. The table below presents our estimate of emissions reduction value.

Table 12 - Estimates of Emissions Reductions Benefits, 2018 Dollars

Pollutant	In Project Opening Year (2025)	Over the Project Lifecycle	
		In Constant Dollars	Discounted @ 7%
Carbon Dioxide (CO2)	$0	$0	$0
Volatile Organic Compounds (VOC)	$85,456	$1,852,003	$609,666
Nitrogen Oxides (NOX)	$87,723	$4,156,497	$1,125,856
Particulate Matter (PM2.5)	$2,741,580	$186,003,395	$45,692,905
Sulfur Dioxide (SO2)	$36,864	$645,785	$240,836
Total	$2,951,624	$192,657,680	$47,669,263

6.5 Safety

The project will also contribute to promoting US DOT's safety long-term outcome by encouraging the use of transit, reducing the VMT through a change in capacity on the roadway, and specific roadway safety improvements to be implemented as part of the project.

6.5.1 Methodology

To quantify the expected level of improvement, a crash analysis was conducted to identify the existing crash issues, identify potential solutions, and estimate the change in the number, rate and consequences of transportation related crashes, serious injuries, and fatalities. Existing crashes were identified from the three most current years available (2016-2018) from the Enhanced Tennessee Roadway Information Management System (ETRIMS) database for the study corridor. There were 3,198 crashes during the three-year period from 2016 through 2018 along the proposed route. Table 13 shows the total number of crashes by mode and severity over the three-year period.

Table 13 – Existing Number of Crashes by Mode and Severity (2016-2018)

Type of Mode	Type of Crash/Severity				Total
	Fatal	Incapacitating Injury	Injury	Property Damage Only	
Pedestrian	3	7	40	6	56
Bicycle	0	0	7	1	8
Motor Vehicle(s) Only	2	24	534	2,574	3,134
Total	5	31	581	2,581	3,198

Figure 5 shows the relative crash density over the project corridor and the relative location of proposed safety improvements.

Figure 5 – Relative Crash Density and Location of Safety Improvements

Union Avenue currently operates as a six-lane undivided urban principal arterial route with left turn restrictions at several key intersections. An element of the Memphis Innovation Corridor is to change the six-lane portion of Union Avenue to a five-lane roadway with two-way left turn lanes and dedicated left turn lanes at signalized intersections. Exclusive turn lanes will be added at the signalized intersections of Union Avenue at East Street, Pauline Street, McNeil Street, Belvedere Street, McLean Street, and Cooper Street. Access management improvements will also be implemented on Union Avenue between McLean Street and East Parkway by reducing and consolidating commercial driveways where practical. The location of the safety improvements is shown within the dashed line in Figure 5.

The potential reduction in the number of crashes was estimated using the Tennessee Department of Transportation's study on Statewide Average Crash Rates for Sections and Spots, which was completed between 2014-2016, and Crash Modification Factors (CMFs) from the American Association of State Highway and Transportation Officials' (AASHTO) *Highway Safety Manual* (HSM), 2010. To avoid double counting the benefits associated with crash reduction at intersections or on segments that could be improved using both methods, only the TDOT Statewide Average Crash Rates methodology was included in the benefit cost analysis.

The TDOT average crash rate for a multi-lane undivided urban state route is 3.954 crashes per million vehicle miles traveled (MVMT), while the average crash rate for a multi-lane roadway with a two-way left-turn lane is 3.294 crashes per MVMT. The 2.96-mile segment of Union Avenue between Manassas Street and East Parkway is proposed to be converted from a six-lane undivided road to a five-lane road with a center two way left turn lane.

This segment of roadway had 1,475 crashes during the three years from 2016 to 2018 with an average AADT of 32,489 vehicles per day. This difference between the statewide average crash rates for roads with and without a two way left turn lane indicates that there would be a 17% reduction in the number of crashes along this segment of the corridor. This equates to an average reduction of 82 crashes per year along this segment of Union Avenue. This represents an 8% reduction in the average number of crashes per year along the entire corridor. The anticipated reduction in crashes per year by severity is shown in Table 14.

Table 14 – Estimated Crash Reduction per Year by Severity

Crash Type/Severity	Average Crashes Per Year	Crash Reduction
Property Damage Only (PDO)	860	65
Injury Crashes	194	16
Incapacitating Injury Crashes	10	1
Fatal Crashes	2	0
Total Crashes	1,066	82

6.5.2 Assumptions

The assumptions used in the estimation of safety benefits are summarized in the Table 15.

Table 15 - Assumptions used in the Estimation of Safety Benefits

Variable Name	Value	Source
Cost per Property Damage Only (PDO), 2017	$4,327	US DOT, Benefit-Cost Analysis Guidance for Discretionary Grant Programs, June 2018
Cost per Injury Crash (Severity Unknown), 2017	$174,000	
Cost per Fatality, 2017	$9,600,000	

6.5.3 Benefit Estimates

Crash reduction is the primary monetized benefit in our analysis. Table 16 presents the estimated safety benefits associated with a reduction in crashes.

Table 16 - Estimates of Safety Benefits, in 2018 Dollars

Type of Benefit	In Project Opening Year (2025)	Over the Project Lifecycle	
		In Constant Dollars	Discounted at 7 Percent
Crash Reduction	$2,683,220	$125,841,366	$32,601,829

7.0 Summary of Findings and BCA Outcomes

The tables below summarize the BCA findings. Annual costs and benefits are computed over the lifecycle of the project (34 years). Construction is expected to be completed by 2025. Benefits accrue during the operation of the proposed project, beginning in 2025.

Table 17 - Overall Results of the Benefit Cost Analysis, in 2018 Millions of Dollars

Project Evaluation Metric	7% Discount Rate
Total Discounted Benefits	$105.5
Total Discounted O&M Costs	$28.3
Total Discounted Costs	$58.4
Net Present Value	$18.8
Benefit / Cost Ratio	1.32
Internal Rate of Return (%)	9.1%
Payback Period (years after start of construction)	16

Considering all monetized benefits and costs, the estimated internal rate of return of the project is 9.1 percent. With a 7 percent real discount rate, the $73.8 million investment would result in $18.8 million in Net Present Value and a Benefit/Cost ratio of approximately 1.32.

Table 18 - Benefit Estimates by Long-Term Outcome for the Full Build Alternative

Long-Term Outcomes	Benefit or Impact Categories	Description	7% Discount Rate
State of Good Repair	Roadway pavement cost reduction	Reduction in pavement lifecycle costs	$83,068
Safety	Accident reduction	Crash reduction due to VMT reduction.	$32,601,829
Economic Competitiveness	Travel time savings	Reduction in travel time for select roadway users and transit riders.	-$8,578,044
	Vehicle operating cost savings	Reduction in fuel and maintenance costs of vehicles.	$33,730,175
Environmental Sustainability	Emissions reductions	Reduction in emissions due to VMT reduction.	$47,669,263
Agency Benefits	Fare Revenue	Transit trip revenue; also part of transit trip cost for riders	$3,403,391
Quality of Life	Transit Oriented Development	Greater amenities in station areas due to denser and mixed-use development for greater accessibility.	Subset of travel time savings
	Low Income Mobility*	Portion of travel time savings accruing to low income users	

8.0 BCA Sensitivity Analysis

The BCA outcomes presented in the previous sections rely on assumptions and long-term projections; both of which are subject to considerable uncertainty. The primary purpose of the sensitivity analysis is to help identify the variables and model parameters whose variations have the greatest impact on the BCA outcomes: the "critical variables." The sensitivity analysis can also be used to:

- Evaluate the impact of changes in individual critical variables – how much the final results would vary with reasonable departures from the "preferred" or most likely value for the variable; and
- Assess the robustness of the BCA and evaluate whether the conclusions reached under the "preferred" set of input values are significantly altered by reasonable departures from those values.

The outcomes of the quantitative analysis for the multi modal transportation management strategy using a 7 percent discount rate are summarized in the table below. The table provides the percentage changes in project NPV associated with variations in variables or parameters (listed in row), as indicated in the column headers.

Table 19 - Summary of Quantitative Assessment of Sensitivity

Parameters	Change in Parameter Value	New NPV (Discounted, 7%)	Change in NPV	New B/C Ratio
Value of Travel Time	Lower Bound of Range Recommended by US DOT	$2.4	-83.5%	1.1
	Upper Bound of Range Recommended by US DOT	$23.4	58.7%	2.1
Value of Statistical Life	Lower Bound of Range Recommended by US DOT	$14.7	-0.4%	1.7
	Upper Bound of Range Recommended by US DOT	$14.8	0.4%	1.7
Capital Cost Estimate	25% Reduction	$20.1	36.2%	2.3
Annual O&M Cost Estimate	25% Reduction	$21.5	45.3%	2.0

9.0 Aggregate Annual Benefits and Costs

This section breaks down all benefits associated with the five long-term outcome criteria (State of Good Repair, Economic Completeness, Environmental Sustainability, and Safety) in annual form for the Memphis Innovation Corridor. Supplementary data tables are also provided for some specific benefit categories. For example, tables providing estimates of annual emission reductions are provided under Environmental Sustainability.

Table 20 - Annual Estimates of Total Project Benefits and Cost, in millions of 2018 Dollars

Calendar Year	Project Year	Total Benefits	State of Good Repair	Economic Competitiveness	Environmental Sustainability	Safety Benefits	Agency Fare Revenue	Total Costs Net of Agency Fare Revenue
2021	1	$0.00	$0.000	$0.0	$0.0	$0.000	$0.0	$16.1
2022	2	$0.00	$0.000	$0.0	$0.0	$0.000	$0.0	$15.1
2023	3	$0.00	$0.000	$0.0	$0.0	$0.000	$0.0	$14.1
2024	4	$0.00	$0.000	$0.0	$0.0	$0.000	$0.0	$13.2
2025 (opening)	5	$5.69	$0.003	$1.9	$2.0	$1.788	$0.2	$2.2
2026	6	$5.56	$0.003	$1.8	$2.0	$1.731	$0.2	$2.0
2027	7	$5.42	$0.003	$1.7	$2.1	$1.675	$0.2	$1.9
2028	8	$5.27	$0.003	$1.6	$2.1	$1.619	$0.2	$1.8
2029	9	$5.11	$0.003	$1.5	$2.1	$1.563	$0.2	$1.6
2030	10	$4.95	$0.003	$1.4	$2.1	$1.508	$0.2	$1.5
2031	11	$4.78	$0.003	$1.3	$2.1	$1.454	$0.2	$1.4
2032	12	$4.62	$0.003	$1.2	$2.0	$1.401	$0.2	$1.3
2033	13	$4.45	$0.003	$1.1	$2.0	$1.349	$0.1	$1.2
2034	14	$4.28	$0.003	$1.0	$2.0	$1.298	$0.1	$1.2
2035	15	$4.12	$0.003	$1.0	$1.9	$1.248	$0.1	$1.1
2036	16	$3.95	$0.003	$0.9	$1.9	$1.200	$0.1	$1.0
2037	17	$3.79	$0.003	$0.8	$1.8	$1.153	$0.1	$0.9
2038	18	$3.63	$0.003	$0.8	$1.7	$1.107	$0.1	$0.9
2039	19	$3.48	$0.003	$0.7	$1.7	$1.062	$0.1	$0.8
2040	20	$3.33	$0.003	$0.7	$1.6	$1.018	$0.1	$0.8
2041	21	$3.18	$0.003	$0.6	$1.6	$0.976	$0.1	$0.7
2042	22	$3.04	$0.003	$0.6	$1.5	$0.936	$0.1	$0.7
2043	23	$2.90	$0.003	$0.6	$1.4	$0.896	$0.1	$0.6
2044	24	$2.76	$0.003	$0.5	$1.4	$0.858	$0.1	$0.6
2045	25	$2.63	$0.003	$0.5	$1.3	$0.821	$0.1	$0.5
2046	26	$2.51	$0.003	$0.4	$1.3	$0.786	$0.1	$0.5
2047	27	$2.38	$0.002	$0.4	$1.2	$0.752	$0.1	$0.5
2048	28	$2.27	$0.002	$0.4	$1.2	$0.719	$0.1	$0.4
2049	29	$2.16	$0.002	$0.4	$1.1	$0.687	$0.1	$0.4
2050	30	$2.05	$0.002	$0.3	$1.0	$0.656	$0.1	$0.4
2051	31	$1.95	$0.002	$0.3	$1.0	$0.627	$0.1	$0.4
2052	32	$1.85	$0.002	$0.3	$0.9	$0.599	$0.1	$0.3
2053	33	$1.75	$0.002	$0.3	$0.9	$0.571	$0.0	$0.3
2054	34	$1.66	$0.002	$0.3	$0.9	$0.545	$0.0	$0.3

Table 21 - Annual Summary of Benefits and Cost with Net Benefits

Calendar Year	Project Year	Total Benefits	Total Costs	Undiscounted Net Benefits	Discounted Benefits @ 7%	Discounted Benefits @ 3%
2021	1	$0.0	$18.5	-$18.5	-$16.1	-$17.4
2022	2	$0.0	$18.5	-$18.5	-$15.1	-$16.9
2023	3	$0.0	$18.5	-$18.5	-$14.1	-$16.4
2024	4	$0.0	$18.5	-$18.5	-$13.2	-$15.9
2025 (opening)	5	$8.5	$3.2	$5.3	$3.5	$4.4
2026	6	$8.9	$3.2	$5.7	$3.5	$4.6
2027	7	$9.3	$3.2	$6.1	$3.5	$4.8
2028	8	$9.7	$3.2	$6.5	$3.5	$4.9
2029	9	$10.1	$3.2	$6.8	$3.5	$5.1
2030	10	$10.4	$3.2	$7.2	$3.4	$5.2
2031	11	$10.8	$3.2	$7.6	$3.4	$5.3
2032	12	$11.1	$3.2	$7.9	$3.3	$5.4
2033	13	$11.5	$3.2	$8.3	$3.2	$5.5
2034	14	$11.8	$3.2	$8.6	$3.1	$5.5
2035	15	$12.2	$3.2	$9.0	$3.0	$5.6
2036	16	$12.5	$3.2	$9.3	$2.9	$5.6
2037	17	$12.8	$3.2	$9.6	$2.8	$5.7
2038	18	$13.1	$3.2	$10.0	$2.8	$5.7
2039	19	$13.5	$3.2	$10.3	$2.7	$5.7
2040	20	$13.8	$3.2	$10.6	$2.6	$5.7
2041	21	$14.1	$3.2	$10.9	$2.5	$5.7
2042	22	$14.4	$3.2	$11.2	$2.4	$5.7
2043	23	$14.7	$3.2	$11.5	$2.3	$5.7
2044	24	$15.0	$3.2	$11.8	$2.2	$5.7
2045	25	$15.3	$3.1	$12.1	$2.1	$5.6
2046	26	$15.6	$3.1	$12.4	$2.0	$5.6
2047	27	$15.9	$3.1	$12.7	$1.9	$5.6
2048	28	$16.1	$3.1	$13.0	$1.8	$5.5
2049	29	$16.4	$3.1	$13.3	$1.7	$5.5
2050	30	$16.7	$3.1	$13.6	$1.7	$5.4
2051	31	$17.0	$3.1	$13.9	$1.6	$5.4
2052	32	$17.2	$3.1	$14.1	$1.5	$5.3
2053	33	$17.5	$3.1	$14.4	$1.4	$5.3
2054	34	$17.8	$3.1	$14.7	$1.4	$5.2

Table 22 - Annual BRT Ridership Demand

Calendar Year	Project Year	BRT Ridership	Diverted from Auto	Diverted from Bus	Induced Demand
2021	1	0	0	0	0
2022	2	0	0	0	0
2023	3	0	0	0	0
2024	4	0	0	0	0
2025 (opening)	5	4,449	742	3,708	0
2026	6	4,507	751	3,756	0
2027	7	4,565	761	3,805	0
2028	8	4,625	771	3,854	0
2029	9	4,685	781	3,904	0
2030	10	4,746	791	3,955	0
2031	11	4,807	801	4,006	0
2032	12	4,870	812	4,058	0
2033	13	4,933	822	4,111	0
2034	14	4,997	833	4,165	0
2035	15	5,062	844	4,219	0
2036	16	5,128	855	4,274	0
2037	17	5,195	866	4,329	0
2038	18	5,262	877	4,385	0
2039	19	5,331	888	4,442	0
2040	20	5,400	900	4,500	0
2041	21	5,470	912	4,559	0
2042	22	5,541	924	4,618	0
2043	23	5,613	936	4,678	0
2044	24	5,686	948	4,739	0
2045	25	5,760	960	4,800	0
2046	26	5,835	973	4,863	0
2047	27	5,911	985	4,926	0
2048	28	5,988	998	4,990	0
2049	29	6,066	1,011	5,055	0
2050	30	6,145	1,024	5,121	0
2051	31	6,225	1,037	5,187	0
2052	32	6,305	1,051	5,255	0
2053	33	6,387	1,065	5,323	0
2054	34	6,470	1,078	5,392	0

Table 23 – Annual State of Good Repair Benefit Estimates

Calendar Year	Project Year	Pavement Maintenance Cost Savings	Residual Value	Pavement Maintenance Cost Savings @ 7%	Residual Value @ 7%	Pavement Maintenance Cost Savings @ 3%	Residual Value @ 3%
2021	1	$0	$0	$0	$0	$0	$0
2022	2	$0	$0	$0	$0	$0	$0
2023	3	$0	$0	$0	$0	$0	$0
2024	4	$0	$0	$0	$0	$0	$0
2025 (opening)	5	$4,004	$0	$2,668	$0	$3,353	$0
2026	6	$4,523	$0	$2,817	$0	$3,678	$0
2027	7	$5,046	$0	$2,937	$0	$3,984	$0
2028	8	$5,574	$0	$3,032	$0	$4,272	$0
2029	9	$6,106	$0	$3,104	$0	$4,543	$0
2030	10	$6,642	$0	$3,156	$0	$4,798	$0
2031	11	$7,182	$0	$3,189	$0	$5,038	$0
2032	12	$7,727	$0	$3,207	$0	$5,262	$0
2033	13	$8,277	$0	$3,210	$0	$5,472	$0
2034	14	$8,831	$0	$3,201	$0	$5,668	$0
2035	15	$9,389	$0	$3,180	$0	$5,851	$0
2036	16	$9,952	$0	$3,150	$0	$6,021	$0
2037	17	$10,519	$0	$3,112	$0	$6,179	$0
2038	18	$11,091	$0	$3,067	$0	$6,325	$0
2039	19	$11,667	$0	$3,015	$0	$6,460	$0
2040	20	$12,249	$0	$2,958	$0	$6,584	$0
2041	21	$12,834	$0	$2,897	$0	$6,698	$0
2042	22	$13,425	$0	$2,832	$0	$6,802	$0
2043	23	$14,020	$0	$2,764	$0	$6,897	$0
2044	24	$14,620	$0	$2,694	$0	$6,983	$0
2045	25	$15,225	$0	$2,622	$0	$7,060	$0
2046	26	$15,835	$0	$2,548	$0	$7,129	$0
2047	27	$16,450	$0	$2,474	$0	$7,190	$0
2048	28	$17,069	$0	$2,399	$0	$7,243	$0
2049	29	$17,694	$0	$2,324	$0	$7,290	$0
2050	30	$18,323	$0	$2,250	$0	$7,329	$0
2051	31	$18,958	$0	$2,175	$0	$7,362	$0
2052	32	$19,597	$0	$2,102	$0	$7,389	$0
2053	33	$20,242	$0	$2,029	$0	$7,410	$0
2054	34	$20,892	$0	$1,957	$0	$7,425	$0

Table 24 - Annual Benefits for Economic Competitiveness

Calendar Year	Project Year	Automobile	BRT	Automobile @ 7%	BRT @ 7%	Automobile @ 3%	BRT @ 3%
2021	1	$0	$0	$0	$0	$0	$0
2022	2	$0	$0	$0	$0	$0	$0
2023	3	$0	$0	$0	$0	$0	$0
2024	4	$0	$0	$0	$0	$0	$0
2025 (opening)	5	-$408,757	$3,305,120	-$272,372	$2,202,341	-$342,328	$2,767,986
2026	6	-$462,152	$3,351,692	-$287,805	$2,087,265	-$375,772	$2,725,232
2027	7	-$516,070	$3,398,928	-$300,357	$1,978,207	-$407,390	$2,683,145
2028	8	-$570,516	$3,446,837	-$310,323	$1,874,851	-$437,253	$2,641,713
2029	9	-$625,494	$3,495,430	-$317,970	$1,776,899	-$465,426	$2,600,928
2030	10	-$681,008	$3,544,715	-$323,542	$1,684,069	-$491,975	$2,560,778
2031	11	-$737,062	$3,594,704	-$327,264	$1,596,092	-$516,960	$2,521,253
2032	12	-$793,659	$3,645,406	-$329,340	$1,512,714	-$540,443	$2,482,344
2033	13	-$850,804	$3,696,832	-$329,956	$1,433,695	-$562,482	$2,444,042
2034	14	-$908,501	$3,748,992	-$329,283	$1,358,807	-$583,132	$2,406,335
2035	15	-$966,755	$3,801,897	-$327,473	$1,287,834	-$602,449	$2,369,216
2036	16	-$1,025,568	$3,855,557	-$324,669	$1,220,571	-$620,486	$2,332,675
2037	17	-$1,084,946	$3,909,983	-$320,996	$1,156,823	-$637,291	$2,296,703
2038	18	-$1,144,892	$3,965,187	-$316,572	$1,096,407	-$652,916	$2,261,291
2039	19	-$1,205,412	$4,021,180	-$311,501	$1,039,149	-$667,407	$2,226,430
2040	20	-$1,266,508	$4,077,972	-$305,878	$984,884	-$680,811	$2,192,111
2041	21	-$1,328,186	$4,135,576	-$299,789	$933,454	-$693,170	$2,158,326
2042	22	-$1,390,449	$4,194,004	-$293,311	$884,712	-$704,529	$2,125,067
2043	23	-$1,453,303	$4,253,267	-$286,514	$838,517	-$714,929	$2,092,326
2044	24	-$1,516,750	$4,313,378	-$279,460	$794,736	-$724,408	$2,060,093
2045	25	-$1,580,797	$4,374,348	-$272,206	$753,243	-$733,007	$2,028,362
2046	26	-$1,645,447	$4,436,190	-$264,802	$713,918	-$740,762	$1,997,124
2047	27	-$1,710,704	$4,498,917	-$257,294	$676,647	-$747,709	$1,966,372
2048	28	-$1,776,574	$4,562,541	-$249,720	$641,324	-$753,883	$1,936,098
2049	29	-$1,843,060	$4,627,077	-$242,117	$607,846	-$759,316	$1,906,294
2050	30	-$1,910,167	$4,692,535	-$234,517	$576,117	-$764,042	$1,876,954
2051	31	-$1,977,900	$4,758,931	-$226,947	$546,045	-$768,092	$1,848,069
2052	32	-$2,046,264	$4,826,278	-$219,431	$517,544	-$771,495	$1,819,634
2053	33	-$2,115,263	$4,894,589	-$211,990	$490,533	-$774,281	$1,791,640
2054	34	-$2,184,901	$4,963,879	-$204,644	$464,932	-$776,478	$1,764,080

Table 25 - Annual Benefits for Environmental Sustainability from Emissions Reductions

Calendar Year	Project Year	Reduction in Air Emissions	Reduction in Air Emissions @ 7%	Reduction in Air Emissions @ 3%
2021	1	$0	$0	$0
2022	2	$0	$0	$0
2023	3	$0	$0	$0
2024	4	$0	$0	$0
2025 (opening)	5	$2,951,624	$1,966,792	$2,471,938
2026	6	$3,250,165	$2,024,040	$2,642,682
2027	7	$3,541,320	$2,061,080	$2,795,550
2028	8	$3,825,293	$2,080,706	$2,931,769
2029	9	$4,102,277	$2,085,390	$3,052,479
2030	10	$4,372,449	$2,077,319	$3,158,750
2031	11	$4,635,974	$2,058,428	$3,251,579
2032	12	$4,893,007	$2,030,424	$3,331,900
2033	13	$5,143,695	$1,994,813	$3,400,588
2034	14	$5,388,175	$1,952,923	$3,458,464
2035	15	$5,626,579	$1,905,917	$3,506,298
2036	16	$5,859,031	$1,854,819	$3,544,810
2037	17	$6,085,651	$1,800,525	$3,574,679
2038	18	$6,306,555	$1,743,815	$3,596,540
2039	19	$6,521,851	$1,685,370	$3,610,991
2040	20	$6,731,648	$1,625,781	$3,618,593
2041	21	$6,936,049	$1,565,558	$3,619,872
2042	22	$7,135,154	$1,505,138	$3,615,324
2043	23	$7,329,061	$1,444,900	$3,605,412
2044	24	$7,517,864	$1,385,160	$3,590,574
2045	25	$7,701,658	$1,326,191	$3,571,218
2046	26	$7,880,533	$1,268,217	$3,547,730
2047	27	$8,054,578	$1,211,426	$3,520,469
2048	28	$8,223,880	$1,155,972	$3,489,774
2049	29	$8,388,525	$1,101,976	$3,455,961
2050	30	$8,548,596	$1,049,537	$3,419,329
2051	31	$8,704,177	$998,727	$3,380,154
2052	32	$8,855,347	$949,601	$3,338,698
2053	33	$9,002,188	$902,193	$3,295,205
2054	34	$9,144,777	$856,527	$3,249,902

Table 26 - Annual Safety Benefits

Calendar Year	Project Year	Crash Reduction Cost Savings	Crash Reduction Cost Savings @ 7%	Crash Reduction Cost Savings @ 3%
2021	1	$0	$0	$0
2022	2	$0	$0	$0
2023	3	$0	$0	$0
2024	4	$0	$0	$0
2025 (opening)	5	$2,683,220	$1,787,943	$2,247,155
2026	6	$2,779,890	$1,731,176	$2,260,305
2027	7	$2,877,332	$1,674,633	$2,271,393
2028	8	$2,975,552	$1,618,503	$2,280,513
2029	9	$3,074,555	$1,562,948	$2,287,758
2030	10	$3,174,348	$1,508,110	$2,293,216
2031	11	$3,274,935	$1,454,110	$2,296,973
2032	12	$3,376,322	$1,401,054	$2,299,111
2033	13	$3,478,516	$1,349,028	$2,299,709
2034	14	$3,581,521	$1,298,108	$2,298,842
2035	15	$3,685,345	$1,248,354	$2,296,585
2036	16	$3,789,992	$1,199,814	$2,293,007
2037	17	$3,895,469	$1,152,529	$2,288,177
2038	18	$4,001,781	$1,106,526	$2,282,160
2039	19	$4,108,935	$1,061,827	$2,275,018
2040	20	$4,216,936	$1,018,445	$2,266,811
2041	21	$4,325,792	$976,388	$2,257,598
2042	22	$4,435,507	$935,656	$2,247,435
2043	23	$4,546,088	$896,246	$2,236,374
2044	24	$4,657,541	$858,148	$2,224,468
2045	25	$4,769,873	$821,351	$2,211,765
2046	26	$4,883,090	$785,838	$2,198,314
2047	27	$4,997,198	$751,590	$2,184,159
2048	28	$5,112,204	$718,586	$2,169,345
2049	29	$5,228,113	$686,802	$2,153,914
2050	30	$5,344,934	$656,214	$2,137,905
2051	31	$5,462,671	$626,793	$2,121,357
2052	32	$5,581,332	$598,512	$2,104,309
2053	33	$5,700,923	$571,343	$2,086,794
2054	34	$5,821,451	$545,254	$2,068,847