MEMORANDUM

To: Aaron Bland, Paul Ray, City of Brevard

From: Heather Maloney, Mike Sellinger, David Wasserman, Matt Hayes, Alta Planning + Design

Date: 4/9/2022

Re: Draft RAISE Benefit-Cost Analysis Memo

Benefit-Cost Analysis for Ecusta Trail RAISE Grant Application

Executive Summary

This Benefit-Cost Analysis (BCA) includes the benefits and costs for the proposed section of the Ecusta Trail project in Transylvania County that would be constructed if the RAISE grant is awarded. The analysis period was 27 years (seven years of construction and 20 years of operation) and assumes a useful service life of 30 years for the project. All costs and benefits are presented in 2020 year dollars.

The following categories of benefits were considered in the BCA:

- **Safety:** The expected reduction in collisions and associated costs.
- **Environmental Sustainability:** Includes reductions in the following pollutants that impact air quality, CO_2, NO_X SO_2, and $PM_{2.5}$.
- **Quality of Life:** The expected reduction in mortality rates due to increased physical activity from new users of the project.
- **Economic Competitiveness:** Includes savings in household transportation costs and traffic congestion costs.
- **State of Good Repair:** Includes reductions in roadway maintenance costs.
- **Maintenance costs (dis-benefit):** Covers the ongoing costs of upkeep to the proposed project

Result Summary

Table 1 displays the total benefits by category included in the BCA. The capital costs included in the BCA are $19.6 million. This BCA estimates that the proposed project compared to the no-build scenario over a 26-year evaluation (2022-2047) and at a 7 percent real discount rate has a net present value of **$11.4 million** and a benefit-cost ratio of **1.77 : 1.0.**

Table 1. Total Undiscounted Benefits over 20 years of Operation

CATEGORY	MONETARY VALUE (In 2020 dollars)
Safety Benefits	**$41,400,000**
Environmental Sustainability	**$83,600**
Quality of Life	**$32,350,000**
Economic Competitiveness	**$803,000**
State of Good Repair	**$105,200**
Maintenance Costs	**$(3,200,000)**
Residual Value	**$6,529,000**
TOTAL BENEFITS (UNDISCOUNTED)	**$78,070,000**

Table 2. Benefit-Cost Analysis Summary

CATEGORY	DISCOUNTED [1] VALUE (in 2020 dollars)
Net Discounted Benefits	**$26,060,000**
Net Discounted Capital Costs	**$14,710,000**
Net Present Value	**$11,350,000**
Benefit - Cost Ratio	**1.77**

Background

The benefit-cost analysis (BCA) for this project follows the principles documented in the USDOT Benefit-Cost Analysis Guidance for Discretionary Grant Programs (March 2022 Revised), and uses the recommended parameter values where applicable. The BCA includes the benefits and costs for the proposed project that would be fully constructed if the RAISE grant is awarded. The analysis period was 27 years (seven years of construction and 20 years of operation) and assumes a useful service life of 30 years for the project. All costs and benefits are presented in 2020 base year dollars. Benefits and cost streams were discounted using a 7% per year discount rate, with the exception of carbon benefits which were discounted at 3% per year. This memo contains a detailed explanation of the BCA methodology and the parameter values that were used.

[1] A 7% discount rate was used for all benefits and costs with the exception of carbon benefits which were discounted at 3% per year.

Approach to Benefits and Study Area

This BCA approach expands on the methods suggested by the National Cooperative Highway Research Program (NCHRP) Report 552: Guidelines for Analysis of Investments in Bicycle Facilities by incorporating detailed local demographic information and using new data and research that has become available since Guidelines for Analysis was published in 2006.

While construction of the project will benefit all residents of and visitors to the region, those living within three miles (about a 15-minute bike ride) and one-half mile (about a 10-minute walk) of the project will have the most convenient access and will gain the most from its completion. Accordingly, this BCA focuses on the bicycling and walking benefits attributed to residents living within three miles of the project and on the walking benefits attributed to residents living within one-half mile project. There are several benefit categories that benefit the region more widely (reduced roadway maintenance, healthcare costs), but these ranges are used to constrain this analysis to the main beneficiaries.

Benefits were primarily calculated by comparing walking and biking activity (including collisions) under the baseline to a Build scenario in which the Ecusta Trail project has been implemented. The baseline and build scenarios encompass an identical geography (Census Tracts within 3 miles of the project). **The benefits included in the Net Present Value and Benefit-Cost Ratio calculations are the net difference between the two scenarios.**

Table 3: Summary Matrix

Baseline	Build Scenario	Type of Impacts
Walking and biking activity within 3 miles of the study area.	Construction of multi-use trail to extend the trail network in the study area and the estimated impacts on walking and biking activity within 3 miles of the study area.	Reduced pollution, reduced healthcare costs, reduced bicycle and pedestrian collisions, reduced roadway maintenance, reduced traffic congestion, and reduced household transportation costs

Costs

Refer to the main application for a detailed breakdown of project costs. The capital cost schedule is shown in **Table 4.** This schedule includes design, engineering, permitting, contracting and installation.

Table 4. Project Construction Schedule and Cost

Construction Year	Anticipated Cost
2022	$61,000
2023	$583,000
2024	$1,600,000
2025	$1,273,000
2026	$6,065,000
2027	$2,001,000
Total Capital Costs	**$19,588,000**

The estimated maintenance costs are $20,300 per mile per year. These values were determined based on maintenance costs of similar facilities throughout the North Carolina and South Carolina region. The total annual maintenance costs included in the BCA were $161,000 per year (undiscounted) and they were included as a disbenefit in the benefit-cost ratio.

Useful Life

The expected useful life of the proposed trail facilities is 30 years. The window of analysis used was 20 years. A residual value of $6,529,000 (undiscounted) was claimed as a benefit in the final year of the analysis period, assuming linear depreciation.

Demand

To understand the benefits of the proposed project, a demand analysis was conducted to estimate the expected number of biking and walking trips that would occur after the project is implemented. The primary inputs to the demand analysis were counts of pedestrians and bicyclists at a location on the existing Estatoe Trail, close to the proposed project.

Table 5: Trail Counts on Estatoe Trail near proposed Ecusta Trail trailhead

Trail (Location)	Count Location	Average Annual Daily Pedestrians	Average Annual Daily Bicyclists	Total Average Annual Daily Users	Count Method	Source
Estatoe Trail	35°15'26.2" N 82°42'28.0"W*	139	79	218	Eco-Counter (continuous bike & pedestrian counting sensor)	Eco-Visio Dashboard via Institute for Transportation Research & Education**

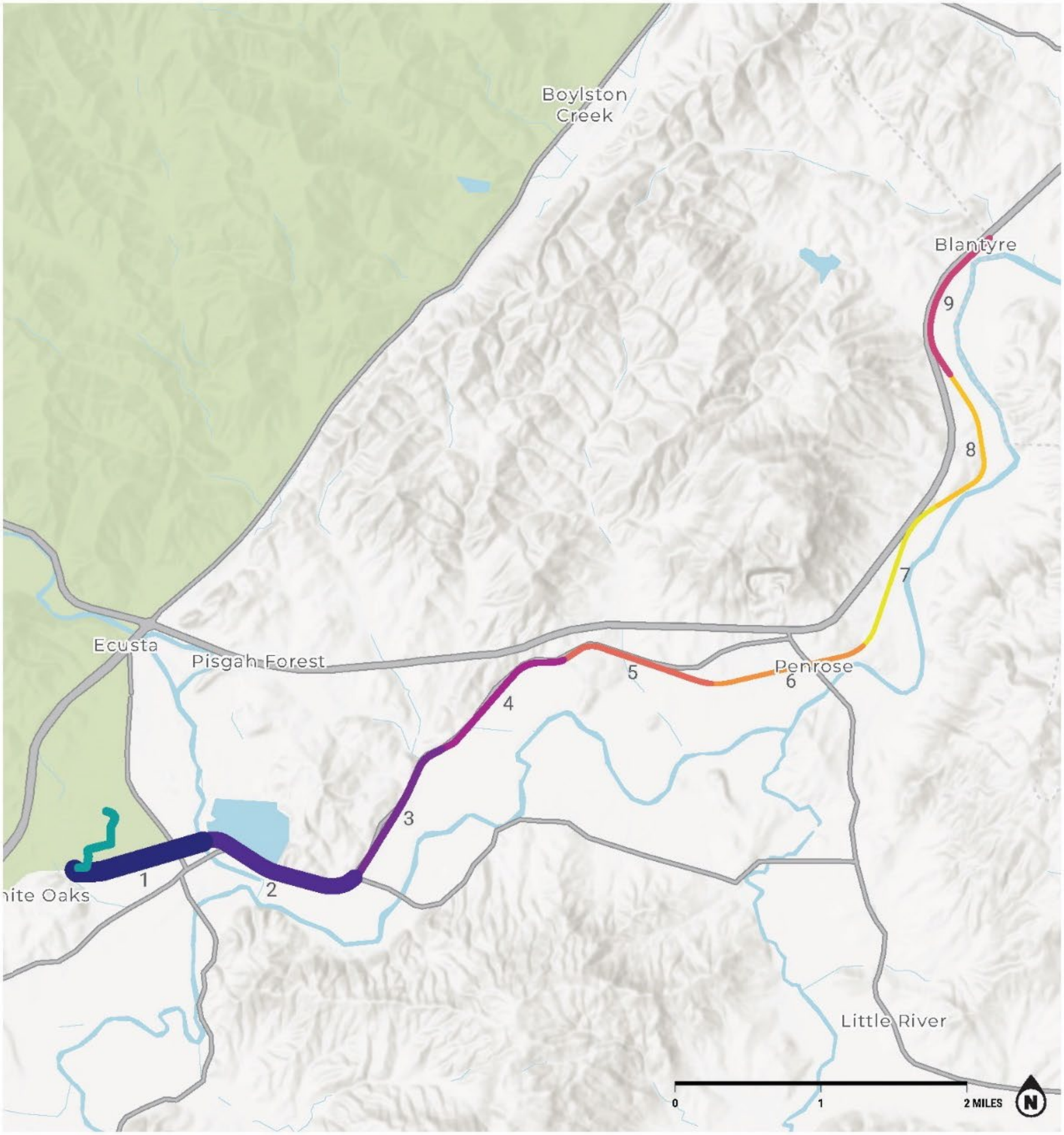
* https://goo.gl/maps/9EN83C1YfgWbJVnX7

** https://itre.ncsu.edu/focus/bike-ped/nc-nmvdp/

Creating context sensitive estimates of demand based on existing counts often requires extrapolating based on other datasets to understand how demand changes throughout a corridor. Powerful proxy metrics for demand and modeshift potential include looking at the rates of Active Trip Potential (ATP) trips, or vehicle trips shorter than three miles. Using the average daily volumes collected between 2015 and 2020 from a counter on an existing segment of the trail, bicycle and pedestrian trip counts were scaled and applied to mile-long segments of the proposed trail by leveraging ATP trips to create adjustment factors. Replica Places' activity-based model outputs for a typical Thursday in 2019 were used to collect information on ATP trips. Details of Replica's modeling approach are articulated in **Appendix A.** ATP trips evaluated included those that terminate within a 1-mile buffer of the proposed trail segment relative to the baseline number of ATP trips occurring within a similar 1-mile buffer area around the existing trail segment. These estimated counts were then summed up for all segments along the proposed trail and divided by the average bicycle and pedestrian trip length from the 2017 National Household Travel Survey to account for unique trips (2.38 miles and 0.86 miles, respectively). In a sentence, we compute the person-miles traveled based on the estimated counts on these "synthetic counters", and then divide them by the average trip distances to get an estimate of unique user trips.

Table 6. Demand Estimate

Project Name	Daily Pedestrian Estimate	Daily Pedestrian Share	Daily Bicyclist Estimate	Daily Bicyclist Share	Overall Estimate (Average Daily Users)
Ecusta Trail	556	79%	151	21%	707



TRAIL SEGMENT REFERENCE

ECUSTA TRAIL
BREVARD, NC

TRAIL SEGMENTS

Baseline Trail Count Segment

ESTIMATED TRAIL SEGMENT DEMAND

Greater number of trips

Lower number of trips

Segment ID	Estimated Pedestrian Trips	Estimated Bike Trips
1	163	122
2	126	94
3	43	32
4	36	27
5	28	21
6	19	14
7	15	11
8	16	12
9	31	23

Benefits

Walking and Biking Activity

The BCA estimated current levels of walking and biking within the project area using American Community Survey (ACS) data. **Table 7** displays the existing commute to work mode share for people within walking and biking distance of the proposed project. Population and demographic forecasts from the Land of Sky Rural Planning Organization (LOSRPO) at the Transportation Analysis Zone (TAZ) level were used to estimate population growth in the study area over the analysis period. Population forecasts were estimated for 2025 and 2045, and were interpolated for each intermediate year in the analysis. For school enrollment forecasts, (negative) growth trends based on historic school enrollment from the area schools from 2004 to 2018 were applied to the total enrollment in 2015 in the study area's TAZs to extrapolate 2045 estimates. A similar growth trend in college enrollment, based on ACS data from 2010 to 2020, was applied to 2015 TAZ estimates and extrapolated to 2045.

Table 7. Means of Transportation to Work of People Living in the Study Area (2019 American Community Survey)

GSP Corridor	Population	Drove Alone	Carpool	Public Transit	Bicycled	Walked	Other
Walkshed (within half-mile)	2,001	81.8%	6.9%	0.0%	1.8%	2.6%	0.5%
Bikeshed (within 3 miles)	18,311	82.4%	7.3%	0.1%	1.0%	2.2%	0.5%

The means of transportation to work data was converted to daily estimates and extrapolated to annual trip volumes and broken into different trip types (i.e. commute, school, college, and utilitarian) using the existing travel patterns (**Table 7**) and data from the National Household Transportation Survey (**Table 8**). The annual extrapolations account for the expected number of trips per week by trip type (i.e., commute, school, and college trips are expected five out of seven days a week, and other trip types are expected to occur seven days a week).

Table 8: Trip Purpose Multiplier[2]

	Bike	Walk
Utilitarian Trip Multiplier	5.33	8.77

Increase in Walking and Biking Activity

The Baseline assumes that the walking and biking mode share will remain constant and that trips will increases annually with expected population growth. In the Build scenario, the demand estimates for the proposed project **(Table 6)** were added to the existing walking and biking activity starting in 2029 (the expected opening year). The demand estimates were escalated by the expected population growth factor each year.

[2] Travel Day Person Trips (in millions), NHTSA 2017 https://nhts.ornl.gov/

Decrease in Motor Vehicle Trips

Some of the estimated annual bicycle and pedestrian trips within the proposed project area are expected to replace motor vehicle trips. Calibrated to modal shift factors reported in literature[3], a univariate regression model estimates the motor vehicle trip replacement factor based on the percentage of trips that terminate in census block groups within ¼-mile of the proposed facility that are less than 4 miles. The details of this confidential model are outlined in **Appendix B**. Trip distance data is provided by Replica for a typical travel Thursday in Fall 2019[4]. The motor vehicle trip replacement factor for all active mode trips is **0.201.**

To estimate the number of vehicle-miles that might be replaced by bicycling and walking trips, **Table 9** shows the average trip distance of bicycling and walking trips by trip purpose. The number of vehicle miles reduced due to bicycle and pedestrian trips was calculated by multiplying the number of biking or walking trips by the trip replacement and trip distance factors.

Table 9: Trip Distance (miles)

	Bike	Walk
Commute Trips[5]	2.47	0.72
College Trips[6]	1.31	0.43
K-12 School Trips[7]	1.36	0.69
Utilitarian Trips[8]	2.28	0.83
Social/Recreational Trips[9]	2.73	1.12

Environmental Sustainability Benefits

For every vehicle-mile reduced, there is an assumed decrease in greenhouse gases and criteria pollutants. **Table 10** lists the reduction in greenhouse gases and criteria pollutants by vehicle-mile traveled. The cost to mitigate or clean-up those pollutants was calculated using the monetary values provided by the 2022 USDOT BCA Guidance Table A-6 for the corresponding year. Emissions types not listed in that table were not included in the analysis.

[3] Volker et al (2019). Quantifying Reductions in Vehicle Miles Traveled from New Bike Paths, Lanes, and Cycle Tracks
[4] Replica Places (2019). https://replicahq.com/
[5] NHTS (2017). http://nhts.ornl.gov/tables09/fatcat/2009/aptl_TRPTRANS_WHYTRP1S.html
[6] Ibid.
7 Safe Routes National Center for Safe Routes to School, Trends in Walking and Bicycling to School from 2007 to 2013 (2015). http://www.saferoutesinfo.org/sites/default/files/SurveyTrends_2007-13_final1.pdf
8 NHTS (2017). http://nhts.ornl.gov/tables09/fatcat/2009/aptl_TRPTRANS_WHYTRP1S.html
9 Ibid

alta

Table 100: Environmental Sustainability Multipliers

	Value (metric tons/VMT)
Particulate Matter 2.5 ($PM_{2.5}$) [i]	0.0000000044
Nitrous Oxides (NOx) [ii]	0.0000008
Sulfur Oxides (SO_2) [iii]	0.00000001
Carbon Dioxide[iv]	0.00044

Quality of Life Benefits

More people bicycling and walking can help encourage an increase in physical activity levels, increased cardiovascular health, and other positive outcomes for users. The benefits from reduced mortality were calculated using the recommended values provided in the 2022 USDOT BCA Guidance (Table A-12) and the national distribution of age ranges and travel patterns. These benefits were only applied to the estimated number of walking and biking trips induced by the project (see **Demand** section). **Table 11** displays the multipliers that were used.

Table 111: Mortality Reduction Multipliers

Mortality Reduction Benefits of Induced Active Transportation	Value
Walking Value per Induced Trip	$7.08
Cycling Value per Induced Trips	$6.31
Walking Ae Proportion (20-74 years old)	68%
Cycling Age Proportion (20-64 years old)	59%
Trips induced from non-active modes	89%

Economic Competitiveness Benefits

For every vehicle-mile reduced, there is a reduction in household transportation costs and congestion costs. ***Table 12*** displays the multipliers use to calculate economic competitiveness benefit.

Table 122: Economic Competitiveness Multipliers

	Value
Household Transportation Cost Savings	**$0.43 per VMT**[10]
Congestion Cost Savings	$0.06 per VMT[11,12]

Safety Benefits

The proposed project would decrease conflicts between people walking and biking with motor vehicles. Collision data was covering a five-year period between 2015 and 2019 was extracted from the Bicyclist and Pedestrian Crash Map maintained by the North Carolina Department of Transportation. Collisions under consideration all involved a bicycle and/or pedestrian and were located within the immediate vicinity of proposed project where it would be expected that people walking and biking would use the proposed project facilities when implemented **(Table 13**). The Crash Reduction Factor (CRF) Install Shared Use Path (CM ID: R37) was applied to the selected crashes and the benefits were monetized using the values provided in the 2022 USDOT BCA Guidance Table A-1 on MAIS Level data.

Table 133. Summary of Collisions

Trail (Location)	Number of Collisions (2015-19)	Fatal	Critical	Severe	Serious	Moderate	Minor	Property Damage Only	Maximum Collision Buffer Distance	Rationale
Ecusta Trail	5	1	-	-	1	-	3	-	0.25 Mile	Closes existing trail gap multiple destinations served
Annual Average	1	0.2	0	0	0.2	0	0.6	0		

[10] Our Driving Costs, AAA (2016). http://exchange.aaa.com/automobiles-travel/automobiles/driving-costs/#.Vw_xCPkrKUk
[11] Crashes vs. Congestion: What's the Cost to Society? AAA (2011). http://www.camsys.com/pubs/2011_AAA_CrashvCongUpd.pdf
[12] Crashes vs. Congestion: What's the Cost to Society? AAA (2011). http://www.camsys.com/pubs/2011_AAA_CrashvCongUpd.pdf

Economic Competitiveness Benefits

Table 14 shows the estimated roadway maintenance cost savings associated with a reduction in vehicle-miles traveled.

Table 144: State of Good Repair Multiplier

	Value (metric tons/VMT)
Roadway Maintenance Cost Savings	$0.06 per VMT[v]

Results

Table 15 through Table 24 display the results of the benefit-cost analysis for each year of the analysis period. This BCA estimates that the proposed project compared to the no-build scenario over a 26-year evaluation (2023-2048) and at a 7 percent real discount rate has a net present value of **$11.6 million** and a benefit-cost ratio of **1.8 : 1.0.**

Table 155: Estimated Annual Bicycle and Walk Trips

Year	Baseline	Build Scenario	Additional Trips
2022	570,000	570,000	-
2023	570,000	570,000	-
2024	580,000	580,000	-
2025	580,000	580,000	-
2026	590,000	590,000	-
2027	590,000	590,000	-
2028	600,000	600,000	-
2029	600,000	950,000	350,000
2030	610,000	960,000	350,000
2031	610,000	970,000	360,000
2032	620,000	980,000	360,000
2033	630,000	990,000	360,000
2034	630,000	1,000,000	370,000
2035	640,000	1,010,000	370,000
2036	640,000	1,020,000	380,000
2037	650,000	1,030,000	380,000
2038	650,000	1,040,000	390,000
2039	660,000	1,050,000	390,000
2040	660,000	1,060,000	400,000
2041	670,000	1,070,000	400,000
2042	670,000	1,080,000	410,000
2043	680,000	1,090,000	410,000
2044	680,000	1,100,000	420,000
2045	690,000	1,110,000	420,000
2046	690,000	1,120,000	430,000
2047	700,000	1,130,000	430,000
2048	710,000	1,140,000	430,000
		Total Additional Trips:	$ 7,810,000

Table 166: Estimated Annual Vehicle Miles Reduced

Year	Baseline	Build Scenario	Additional Vehicle Miles Reduced
2022	210,000	210,000	-
2023	215,000	215,000	-
2024	217,000	217,000	-
2025	219,000	219,000	-
2026	221,000	221,000	-
2027	224,000	224,000	-
2028	226,000	226,000	-
2029	228,000	299,000	71,000
2030	230,000	303,000	73,000
2031	232,000	306,000	74,000
2032	234,000	309,000	75,000
2033	236,000	312,000	76,000
2034	238,000	315,000	77,000
2035	241,000	318,000	77,000
2036	243,000	322,000	79,000
2037	245,000	325,000	80,000
2038	247,000	328,000	81,000
2039	249,000	331,000	82,000
2040	251,000	334,000	83,000
2041	253,000	337,000	84,000
2042	255,000	341,000	86,000
2043	257,000	344,000	87,000
2044	260,000	347,000	87,000
2045	262,000	350,000	88,000
2046	264,000	353,000	89,000
2047	266,000	356,000	90,000
2048	268,000	360,000	92,000
		Total Additional Vehicle Miles Reduced:	1,631,000

Table 17: Estimated Annual Environmental Sustainability Benefits (Undiscounted)

Year	Baseline	Build Scenario	Benefits
2022	$-	$-	$-
2023	$-	$-	$-
2024	$-	$-	$-
2025	$-	$-	$-
2026	$-	$-	$-
2027	$-	$-	$-
2028	$-	$-	$-
2029	$10,500	$13,800	$3,300
2030	$10,800	$14,200	$3,400
2031	$11,000	$14,500	$3,500
2032	$11,200	$14,700	$3,500
2033	$11,400	$15,000	$3,600
2034	$11,600	$15,300	$3,700
2035	$11,800	$15,600	$3,800
2036	$12,100	$16,100	$4,000
2037	$12,300	$16,400	$4,100
2038	$12,500	$16,700	$4,200
2039	$12,800	$17,000	$4,200
2040	$13,000	$17,300	$4,300
2041	$13,200	$17,600	$4,400
2042	$13,400	$17,900	$4,500
2043	$13,800	$18,400	$4,600
2044	$14,000	$18,700	$4,700
2045	$14,200	$19,000	$4,800
2046	$14,500	$19,400	$4,900
2047	$14,700	$19,700	$5,000
2048	14,900	20,000	$5,100
		Total Benefits:	$ 83,600

Table 18: Estimated Annual Quality of Life Benefits (Undiscounted)

Year	Baseline	Build Scenario	Benefits
2022	$-	$-	$-
2023	$-	$-	$-
2024	$-	$-	$-
2025	$-	$-	$-
2026	$-	$-	$-
2027	$-	$-	$-
2028	$-	$-	$-
2029	$2,160,000	$3,580,000	$1,420,000
2030	$2,180,000	$3,620,000	$1,440,000
2031	$2,200,000	$3,660,000	$1,460,000
2032	$2,220,000	$3,700,000	$1,480,000
2033	$2,240,000	$3,740,000	$1,500,000
2034	$2,260,000	$3,780,000	$1,520,000
2035	$2,280,000	$3,820,000	$1,540,000
2036	$2,290,000	$3,860,000	$1,570,000
2037	$2,310,000	$3,900,000	$1,590,000
2038	$2,330,000	$3,940,000	$1,610,000
2039	$2,350,000	$3,980,000	$1,630,000
2040	$2,370,000	$4,020,000	$1,650,000
2041	$2,390,000	$4,060,000	$1,670,000
2042	$2,410,000	$4,100,000	$1,690,000
2043	$2,430,000	$4,140,000	$1,710,000
2044	$2,450,000	$4,180,000	$1,730,000
2045	$2,470,000	$4,220,000	$1,750,000
2046	$2,490,000	$4,260,000	$1,770,000
2047	$2,500,000	$4,300,000	$1,800,000
2048	$2,520,000	$4,340,000	$1,820,000
		Total Benefits:	$ 32,350,000

Table 19: Estimated Annual Economic Competitiveness Benefits (Undiscounted)

Year	Baseline	Build Scenario	Benefits
2022	$-	$-	$-
2023	$-	$-	$-
2024	$-	$-	$-
2025	$-	$-	$-
2026	$-	$-	$-
2027	$-	$-	$-
2028	$-	$-	$-
2029	$112,000	$148,000	$36,000
2030	$113,000	$149,000	$36,000
2031	$114,000	$151,000	$37,000
2032	$115,000	$152,000	$37,000
2033	$116,000	$154,000	$38,000
2034	$117,000	$155,000	$38,000
2035	$119,000	$157,000	$38,000
2036	$120,000	$158,000	$38,000
2037	$121,000	$160,000	$39,000
2038	$122,000	$162,000	$40,000
2039	$123,000	$163,000	$40,000
2040	$124,000	$165,000	$41,000
2041	$125,000	$166,000	$41,000
2042	$126,000	$168,000	$42,000
2043	$127,000	$169,000	$42,000
2044	$128,000	$171,000	$43,000
2045	$129,000	$172,000	$43,000
2046	$130,000	$174,000	$44,000
2047	$131,000	$176,000	$45,000
2048	132,000	177,000	$45,000
		Total Benefits:	**$ 803,000**

Table 20: Estimated Annual Safety Benefits (Undiscounted)

Year	Baseline	Build Scenario	Benefits
2022	$-	$-	$-
2023	$-	$-	$-
2024	$-	$-	$-
2025	$-	$-	$-
2026	$-	$-	$-
2027	$-	$-	$-
2028	$-	$-	$-
2029	$-	$2,070,000	$2,070,000
2030	$-	$2,070,000	$2,070,000
2031	$-	$2,070,000	$2,070,000
2032	$-	$2,070,000	$2,070,000
2033	$-	$2,070,000	$2,070,000
2034	$-	$2,070,000	$2,070,000
2035	$-	$2,070,000	$2,070,000
2036	$-	$2,070,000	$2,070,000
2037	$-	$2,070,000	$2,070,000
2038	$-	$2,070,000	$2,070,000
2039	$-	$2,070,000	$2,070,000
2040	$-	$2,070,000	$2,070,000
2041	$-	$2,070,000	$2,070,000
2042	$-	$2,070,000	$2,070,000
2043	$-	$2,070,000	$2,070,000
2044	$-	$2,070,000	$2,070,000
2045	$-	$2,070,000	$2,070,000
2046	$-	$2,070,000	$2,070,000
2047	$-	$2,070,000	$2,070,000
2048	$-	$2,070,000	$2,070,000
		Total Benefits:	**$ 41,400,000**

Table 21: Estimated Annual State of Good Repair Benefits (Undiscounted)

Year	Baseline	Build Scenario	Benefits
2022	$-	$-	$-
2023	$-	$-	$-
2024	$-	$-	$-
2025	$-	$-	$-
2026	$-	$-	$-
2027	$-	$-	$-
2028	$-	$-	$-
2029	$14,600	$19,300	$4,700
2030	$14,800	$19,500	$4,700
2031	$14,900	$19,700	$4,800
2032	$15,100	$19,900	$4,800
2033	$15,200	$20,100	$4,900
2034	$15,300	$20,300	$5,000
2035	$15,500	$20,500	$5,000
2036	$15,600	$20,700	$5,100
2037	$15,700	$20,900	$5,200
2038	$15,900	$21,100	$5,200
2039	$16,000	$21,300	$5,300
2040	$16,100	$21,500	$5,400
2041	$16,300	$21,700	$5,400
2042	$16,400	$21,900	$5,500
2043	$16,600	$22,100	$5,500
2044	$16,700	$22,300	$5,600
2045	$16,800	$22,500	$5,700
2046	$17,000	$22,700	$5,700
2047	$17,100	$22,900	$5,800
2048	17,200	23,100	$5,900
		Total Benefits:	$ 105,200

Table 22: Estimated Annual Maintenance Disbenefits (Undiscounted)

Year	Baseline	Build Scenario	Benefits
2022			
2023			
2024			
2025			
2026			
2027			
2028			
2029	$-	$ (160,000)	$ (160,000)
2030	$-	$ (160,000)	$ (160,000)
2031	$-	$ (160,000)	$ (160,000)
2032	$-	$ (160,000)	$ (160,000)
2033	$-	$ (160,000)	$ (160,000)
2034	$-	$ (160,000)	$ (160,000)
2035	$-	$ (160,000)	$ (160,000)
2036	$-	$ (160,000)	$ (160,000)
2037	$-	$ (160,000)	$ (160,000)
2038	$-	$ (160,000)	$ (160,000)
2039	$-	$ (160,000)	$ (160,000)
2040	$-	$ (160,000)	$ (160,000)
2041	$-	$ (160,000)	$ (160,000)
2042	$-	$ (160,000)	$ (160,000)
2043	$-	$ (160,000)	$ (160,000)
2044	$-	$ (160,000)	$ (160,000)
2045	$-	$ (160,000)	$ (160,000)
2046	$-	$ (160,000)	$ (160,000)
2047	$-	$ (160,000)	$ (160,000)
2048	$-	$ (160,000)	$ (160,000)
		Total Benefits:	$ (3,200,000)

Table 23: Estimated Annual Benefits (Undiscounted)

Year	Baseline	Build Scenario	Benefits
2022	$-	$-	$-
2023	$-	$-	$-
2024	$-	$-	$-
2025	$-	$-	$-
2026	$-	$-	$-
2027	$-	$-	$-
2028	$-	$-	$-
2029	$2,300,000	$5,670,000	$3,370,000
2030	$2,320,000	$5,720,000	$3,400,000
2031	$2,340,000	$5,760,000	$3,420,000
2032	$2,360,000	$5,800,000	$3,440,000
2033	$2,380,000	$5,840,000	$3,460,000
2034	$2,400,000	$5,880,000	$3,480,000
2035	$2,420,000	$5,920,000	$3,500,000
2036	$2,440,000	$5,960,000	$3,520,000
2037	$2,460,000	$6,000,000	$3,540,000
2038	$2,480,000	$6,050,000	$3,570,000
2039	$2,500,000	$6,090,000	$3,590,000
2040	$2,520,000	$6,130,000	$3,610,000
2041	$2,540,000	$6,170,000	$3,630,000
2042	$2,560,000	$6,210,000	$3,650,000
2043	$2,590,000	$6,260,000	$3,670,000
2044	$2,610,000	$6,300,000	$3,690,000
2045	$2,630,000	$6,350,000	$3,720,000
2046	$2,650,000	$6,390,000	$3,740,000
2047	$2,670,000	$6,430,000	$3,760,000
2048	$2,690,000	$13,000,000	$10,310,000
		Total Benefits:	$ 78,070,000

Table 24: Estimated Discounted Net Costs and Benefits (discounted at 7%)[13]

Year	Net Costs	Net Benefits	Net Cumulative Costs and Benefits
2022	$ (60,000)	$-	$ (60,000)
2023	$ (540,000)	$-	$ (610,000)
2024	$ (1,400,000)	$-	$ (2,000,000)
2025	$ (1,040,000)	$-	$ (3,040,000)
2026	$ (4,630,000)	$-	$ (7,670,000)
2027	$ (5,710,000)	$-	$ (13,380,000)
2028	$ (1,330,000)	$-	$ (14,710,000)
2029	$-	$2,100,000	$ (12,610,000)
2030	$-	$1,980,000	$ (10,630,000)
2031	$-	$1,860,000	$ (8,770,000)
2032	$-	$1,750,000	$ (7,030,000)
2033	$-	$1,640,000	$ (5,380,000)
2034	$-	$1,550,000	$ (3,830,000)
2035	$-	$1,450,000	$ (2,380,000)
2036	$-	$1,370,000	$ (1,010,000)
2037	$-	$1,290,000	$270,000
2038	$-	$1,210,000	$1,480,000
2039	$-	$1,140,000	$2,620,000
2040	$-	$1,070,000	$3,690,000
2041	$-	$1,000,000	$4,690,000
2042	$-	$940,000	$5,630,000
2043	$-	$890,000	$6,520,000
2044	$-	$830,000	$7,360,000
2045	$-	$780,000	$8,140,000
2046	$-	$740,000	$8,880,000
2047	$-	$690,000	$9,570,000
2048	$-	$1,780,000	$11,350,000
Total Net Discounted Costs: $14,710,000		**Total Discounted Net Benefits: $26,060,000**	**Net Present Value: $11,350,000**
			Benefit-Cost Ratio: 1.77

[13] Carbon reduction benefits were discounted at 3%

Multiplier Notes

---

[i] The Safer Affordable Fuel-Efficient Vehicles Rule for MY2021-MY2026 Passenger Cars, BUILD Guidance 2020, Table A-7 and Light Trucks Preliminary Regulatory Impact Analysis (October 2018) https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/ld_cafe_co2_nhtsa_2127-al76_epa_pria_181016.pdf
[ii] The Safer Affordable Fuel-Efficient Vehicles Rule for MY2021-MY2026 Passenger Cars, BUILD Guidance 2020, Table A-7 and Light Trucks Preliminary Regulatory Impact Analysis (October 2018) https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/ld_cafe_co2_nhtsa_2127-al76_epa_pria_181016.pdf
[iii] The Safer Affordable Fuel-Efficient Vehicles Rule for MY2021-MY2026 Passenger Cars, BUILD Guidance 2020, Table A-7 and Light Trucks Preliminary Regulatory Impact Analysis (October 2018) https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/ld_cafe_co2_nhtsa_2127-al76_epa_pria_181016.pdf
[iv] Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866. https://www.whitehouse.gov/sites/default/files/omb/inforeg/scc-tsd-final-july-2015.pdf
[v] Kitamura, R., Zhao, H., and Gubby, A. R. Development of a Pavement Maintenance Cost Allocation Model. Institute of Transportation Studies, University of California, Davis. https://trid.trb.org/view.aspx?id=261768

Appendix A- Replica Methodology

Appendix B- Memo on Context Sensitive Modal Substitution Rate Methodology (Confidential)