Benefit-Cost Analysis Memorandum

Corridor K Improvements in Graham County
US 129, NC 143, NC 28 (A-0009)

2023 NSFLTP Grant Application

Prepared for NCDOT

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Exhibits

Executive Summary

A benefit-cost analysis (BCA) was conducted for Corridor K Improvements in Graham County (hereafter called the Project) to support the North Carolina Department of Transportation's (NCDOT's) grant application for the USDOT 2023 Nationally Significant Federal Lands and Tribal Projects (NSFLTP). NSFLTP does not require a BCA. However, one was conducted in order to strengthen the justification and need of the Project. This analysis was conducted in accordance with the 2023 *Benefit-Cost Analysis Guidance for Discretionary Grant Programs* (Guidance).[1] Capital outlays are scheduled to begin in 2024 and construction is scheduled for completion in 2028. All values are in 2021 dollars discounted at a 7 percent discount rate to 2021 and cover a 20-year operations period, consistent with Guidance.

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

[1] USDOT Benefit Cost Analysis Guidance 2023 Update, https://www.transportation.gov/sites/dot.gov/files/2023-01/Benefit%20Cost%20Analysis%20Guidance%202023%20Update.pdf

Exhibit 1 – Impact Matrix

Current Status/Baseline	Change to Baseline	Benefit	Affected Population	Economic Benefit (NPV, $2021M)	Page Reference in BCA Memo
The Project is the final phase of the Appalachian Regional Commission Corridor K between Andrews, NC and Stecoah, NC. This segment serves as an alternative route to the US 74 corridor through the Nantahala Gorge. Due to the topography of the roadway, there are very limited alternative routes in the area and any major accident along the stretch will reroute to US 74. This can cause multi-hour delays. The narrow roadway also causes longer than normal clearance times for vehicles involved in accidents and emergency service vehicles.	This corridor segment will provide an improved system of transportation for both routine travel and emergency travel in the event of a national crisis by reducing the slope of the roadway as well as widening the road for shoulder pull-offs. The proposed project will restore the good condition of infrastructure and result in travel time savings, delays and detours avoided, emissions savings, emergency response improvements, and improved recreational access.	**Safety Benefits**			
		Reduced Roadway Fatalities and Crashes	All corridor users	$38.9	10
		Emergency Services	All regional users and non-users	$11.1	10
		Wildlife Safety	Wildlife and corridor drivers	Negligible	11
		Economic Competitiveness			
		Auto Travel Time Savings	Corridor auto users	$52.1	11
		Truck Travel Time Savings	Corridor truck drivers	$3.2	11
		Truck Operating Savings	Corridor truck operators	$5.6	11
		Signal Coordination Time Savings	Users in Robbinsville	$2.7	11
		Maintenance Detour Delays Avoided	US 74 users	$11.0	11
		DMS/Trailblazers Detour Delays Avoided	All corridor and US 74 users	$81.8	11
		Agricultural Market Accessibility Benefit	Graham and Swain County farms	$36.4	12
		Climate Change, Resiliency, and the Environment			
		Emissions Savings	All regional users and non-users	$2.1	13
		Equity, Multimodal Options, and Quality of Life			
		Paratransit Travel Time Savings	Graham County transit users	$0.4	13
		Innovation Areas: Technology, Project Delivery, and Financing			
		Resident and Visitor Recreation	Graham County bikers and hikers	$0.2	14
		State of Good Repair			
		Net Operating & Maintenance Cost Savings	NCDOT and NC taxpayers	$8.8	14
		Residual Value	NCDOT and NC taxpayers	$23.8	15

Exhibit 2 summarizes long term outcomes of the Project. Taken in total, the Project provides $244.9 million in benefits over the analysis period, using a 7 percent discount rate. Compared to a similarly discounted cost estimate, the Benefit-Cost Ratio for the Project is 1.13, a solid return on this critical investment for the region. The net benefits of the Project are $33.0 million using a 7 percent discount rate.

Exhibit 2 – Costs and Benefits Delivered by Long-Term Outcomes

Analysis Period: (20 years)	Total Project 7% Discount Rate 2028-2048
Costs (2021$M)	
Capital Cost	$244.9
Total Costs	***$244.9***
Safety Benefits	
Reduced Roadway Fatalities and Crashes	$38.9
Emergency Services	$11.1
Wildlife Safety	Negligible
Subtotal	*$50.0*
Economic Competitiveness	
Auto Travel Time Savings	$52.1
Truck Travel Time Savings	$3.2
Truck Operating Savings	5.6
Signal Coordination Time Savings	$2.7
Maintenance Detour Delays Avoided	$11.0
DMS/Trailblazers Detour Delays Avoided	$81.8
Agricultural Market Accessibility Benefit	$36.4
Sub-Total	*$192.7*
Climate Change, Resiliency, and the Environment	
Emissions Savings	$2.1
Sub-Total	*$2.1*
Equity, Multimodal Options, and Quality of Life	
Paratransit Travel Time Savings	$0.4
Sub-Total	*$0.4*
Innovation Areas: Technology, Project Delivery, and Financing	
Resident and Visitor Recreation	$0.2
Sub-Total	*$0.2*
State of Good Repair	
Net Operating & Maintenance Cost Savings	$8.8
Residual Value	$23.8
Sub-Total	*$32.6*
Total Benefits	***$277.9***
Results	
Net Present Value (2021 $M)	$33.0
Benefit-Cost Ratio	1.13

1. Introduction

Safe, reliable, and affordable transportation is an urgent challenge faced by many across the nation. The Corridor K Improvements in Graham County Project will upgrade the existing roadway and complete the final segment of Appalachian Regional Commission Corridor K between Andrews, NC and Stecoah, NC.[2] This section, formally identified as A-0009C, is one of the last sections of the ADHS to be completed; and acts as a nationally significant corridor for connecting local communities and visitors to the Nantahala National Forest, the Appalachian National Scenic Trail (ANST), and the Great Smoky National Park (11 miles away). The Project is also located within, and provides access to, the National Tribal Transportation Facilities owned by the Eastern Band of Cherokee Indians (EBCI).

The Project is part of a multi-phased project aimed at addressing transportation challenges related to safety, mobility, and access along the corridor to create a safe and efficient facility for all users. Once complete, this corridor will provide for the national economic interests, enhance local economic development opportunities along and near the corridor, and provide an improved system of transportation for both routine travel and emergency travel in the event of a regional crisis. The proposed project will restore the good condition of infrastructure that supports commerce and economic growth; advance national or regional economic development in areas of need; and reduce barriers separating workers from employment centers by reducing transportation network gaps to connect peripheral regions to urban areas and job opportunities.

The Project will consist of a combination of infrastructure and technological improvements to address transportation challenges along the corridor, create a safe and efficient facility for all modes, and address multiple benefits that are consistent with USDOT merit criteria. These include Safety Benefits, Economic Impacts, Freight Movement, and Job Creation, Climate Change, Resiliency, and the Environment, Equity, Multimodal Options, and Quality of Life, Innovation Areas: Technology, Project Delivery, and Financing, and State of Good Repair. In some cases, the expected Project outcomes apply to more than one of the benefit categories.

- ***Safety Benefits***: The Project improves safety in several ways:
  - In instances where the corridor is realigned with a modified slope and added passing and climbing lanes, the improved geometry and right of way will reduce the potential for crashes. This will also reduce emergency response travel times, saving lives and property; and
  - The wildlife and pedestrian bridge will separate wildlife from vehicular traffic, resulting in fewer conflicts and their associated damage.
- ***Economic Competitiveness***: Three types of economic competitiveness benefits are estimated as part of the BCA:
  - The intelligent transportation system (ITS) components will alert drivers of long delays due to incidents on US 74, allowing them the opportunity to reroute, and will provide signal coordination in Robbinsville, both of which will produce travel time savings for commuters;
  - The grade modification and climbing lanes along the corridor will reduce travel time and provide an ease of use for motorists, including commercial vehicles; and
  - The more efficient travel through the corridor results in time savings which will also marginally reduce transportation costs for farms within the region.
- ***Climate Change, Resiliency, and the Environment***: Project improvements that result in travel time savings for users also reduce motorized emissions through a reduction in idling.
- ***Equity, Multimodal Options, and Quality of Life***: Mobility benefits are realized through the Project by paratransit travel time savings.

[2] 2023 Benefit Cost Analysis Guidance. USDOT. Retrieved Online. https://www.transportation.gov/sites/dot.gov/files/2023-01/Benefit%20Cost%20Analysis%20Guidance%202023%20Update.pdf

- ***Innovation Areas: Technology, Project Delivery, and Financing***: The Project increases Quality of Life by enhancing the recreational benefit for trail users by connecting the Appalachian Trail with additional parking spaces.
- ***State of Good Repair***: State of Good Repair benefits include the residual value of the investment and annual operating and maintenance cost savings compared to the No Build.

2. Analysis Framework

The parameters of the benefits analysis follow the protocols set by the Office of Management and Budget (OMB) Circular A-94 as well as the recommended benefit quantification methods by the USDOT and the Federal Emergency Management Agency (FEMA). Generally, standard factors and values accepted by Federal agencies were used for the benefits calculation except in cases where more Project-specific values or prices were available. In all such cases, modifications are noted, and references are provided for data sources. The analysis follows a conservative estimation of the benefits. By adhering to a strict standard of what could be included in the benefits analysis, actual total benefits may be greater than depicted in the results.

The baseline assumes that the Project would not be built, and current conditions and operations would continue in the project area. Under the baseline, the purpose of and need for the Project would not be met and would generally be limited to the operation and maintenance of existing infrastructure. The Project was compared to the baseline to identify benefits and costs.

A custom model was developed to estimate the future benefits for the Project. Benefits were estimated over a 20-year period of analysis beginning when construction ends and concluding after 20 full years of operations. Construction for some project segments started in 2022. The last remaining segment is scheduled to start in 2024, and all construction is scheduled to be completed in 2028.As such, benefits are applied for 2028 through 2048 in the analysis.

The benefits are expressed in constant 2021 dollars, which avoids forecasting future inflation and escalating future values for benefits and costs accordingly. The BCA Guidance deflator and gross domestic product chained price index from the OMB were used to adjust past cost estimates or price values into 2021-dollar terms.[3]

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

3. Analysis Assumptions

A list of assumptions for the Project is provided in the BCA workbook (see Inputs tab in the file A-0009 Benefit Cost Analayis.xlsx) as well as in Exhibit 3.

[3] Table 10.1 – Gross Domestic Product and Deflators Used in the Historical Tables: 1940-2027. Online. https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fwww.whitehouse.gov%2Fwp-content%2Fuploads%2F2022%2F03%2Fhist10z1_fy2023.xlsx&wdOrigin=BROWSELINK

Exhibit 3 – BCA Calculation Inputs

Input	Value	Source
General		
Discount Rate	7%	January 2023 BCA Guidance for Discretionary Grant Programs
SCC Discount Rate - CO2	3%	January 2023 BCA Guidance for Discretionary Grant Programs
Deflator	See "Deflator" Sheet	https://www.whitehouse.gov/wp-content/uploads/2022/03/hist10z1_fy2023.xlsx
Begin Construction year	2023	NCDOT
Complete Construction year	2028	NCDOT
Analysis Period	20	
Dollar Year	2021	January 2023 BCA Guidance for Discretionary Grant Programs
Discount year	2021	January 2023 BCA Guidance for Discretionary Grant Programs
Benefit Year	2028	NCDOT
Factor for half year benefits	0.5	NCDOT
Traffic Data Assumptions		
Percentage of Trucks	6%	TSG Engineers; STIP Project No. A-0009C - Passing and Climbing Lane Documentation
Annualization Factor	320	Assumption
Annualization Factor for paratransit (demand response)	288	Graham County Transit
Annual Growth Rate (CAGR)	1.5%	TSG Engineers; STIP Project No. A-0009C - Passing and Climbing Lane Documentation
Average Corridor Travel Time without Project (hr)	0.25	TSG Engineers; STIP Project No. A-0009C - Passing and Climbing Lane Documentation
Average Corridor Travel Time with Project (hr)	0.13	TSG Engineers; STIP Project No. A-0009C - Passing and Climbing Lane Documentation
Average Corridor Travel Time Savings (hr per veh)	0.12	TSG Engineers; STIP Project No. A-0009C - Passing and Climbing Lane Documentation
US 74 closure per vehicle per instance (hours)	4.52	TIMS Data
US 74 Maintenance detour (hours)	0.3	Google Maps
Net Maintenance time savings (hours) per vehicle	0.5	assumption
NC 143 Maintenance detour (annual frequency)	13	Graham County NC 143, 5-yr Maint. Costs, NCDOT
Average Passenger Vehicle Occupancy, all travel	1.67	January 2023 BCA Guidance for Discretionary Grant Programs
Delay savings with coordinated signals (per trip)	0.40	Source: https://connect.ncdot.gov/resources/safety/Teppl/TEPPL%20All%20Documents%20Library/Signal%20System%20Timing%20Philosophy%20Manual.pdf
State of Good Repair		
Highway and Streets Service Life	45.00	BEA Rate of Depreciation, Service Lives, Declining-Balance Rates, and Hulten-Wykoff Categories
Economic Competitiveness		
Vehicle Maintenance Cost per Mile (Gas, Maintenance, Tires, Depreciation) (2021$/Mile) -- Light Duty Vehicles	$0.46	January 2023 BCA Guidance for Discretionary Grant Programs
Value of Time (2021$), all purposes	$18.80	January 2023 BCA Guidance for Discretionary Grant Programs

Value of Time, (2021$), truck driver per hour	$32.40	January 2023 BCA Guidance for Discretionary Grant Programs
Truck operating costs per hour (2021$)	$55.97	Table 9 ATRI Operational Cost of Trucking 2023. Includes fuel, truck/trailer lease, repair, maintenance, driver benefits, tires, and insurance. Excludes driver time (valued in travel time savings); https://truckingresearch.org/wp-content/uploads/2023/06/ATRI-Operational-Cost-of-Trucking-06-2023.pdf
Value of Time (2021$), bus driver	$35.00	January 2023 BCA Guidance for Discretionary Grant Programs
Average paratransit bus passengers per month	1,505	Graham County Transit Director (email dated 1/23/23)
Average Annual paratransit bus passengers	18,060	Calculation
Average Trip Counts by month (NCDOT)	216	Graham County Transit Director (email dated 1/23/23)
Safety		
PDO Damage values (2021$)	$4,800	January 2023 BCA Guidance for Discretionary Grant Programs
O – No Injury (2021$)	$4,000	January 2023 BCA Guidance for Discretionary Grant Programs
C – Possible Injury (2021$)	$78,500	January 2023 BCA Guidance for Discretionary Grant Programs
B – Non-incapacitating (2021$)	$153,700	January 2023 BCA Guidance for Discretionary Grant Programs
A – Incapacitating (2021$)	$564,300	January 2023 BCA Guidance for Discretionary Grant Programs
K – Killed (2021$)	$11,800,000	January 2023 BCA Guidance for Discretionary Grant Programs
U – Injured (Severity Unknown) (2021$)	$213,900	January 2023 BCA Guidance for Discretionary Grant Programs
# Accidents Reported (Unknown if Injured) (2021$)	$162,600	January 2023 BCA Guidance for Discretionary Grant Programs
Injury crash (2021$)	$307,800	January 2023 BCA Guidance for Discretionary Grant Programs
Fatal crash (2021$)	$13,046,800	January 2023 BCA Guidance for Discretionary Grant Programs
Number of Annual Trail Trips in 2022 - Walking	8,082	Extrapolated data from Appalachian Trail Conservancy
Per Person per mile, pedestrian Improvement	0.11	January 2023 BCA Guidance for Discretionary Grant Programs
Mortality Reduction Benefits Induced Active Transportation - Walking (2021$)	7.2	January 2023 BCA Guidance for Discretionary Grant Programs
Mortality Reduction Benefits Induced Active Transportation - Cycling (2021$)	6.42	January 2023 BCA Guidance for Discretionary Grant Programs
Number of current parking spaces	6	NCDOT
Number of added parking spaces	2	NCDOT
Deer Hit near Wildlife Bridge - Year 2018 (annual)	1	NCDOT
Environmental		
Light Vehicle Idle Emissions Rates (average 3.515,4.065) g/hr. NOx	3.8	Idling Vehicle Emissions for Passenger Cars, Light-Duty Trucks, and Heavy-Duty Trucks Emission Facts, EPA420-F-08-025, October 2008
Light Vehicle Idle Emissions Rates g/hr. CO_2	2,444	Greenhouse Gas Emissions from a Typical Passenger Vehicle, EPA
Heavy Duty (Class VII) Idle Emissions Rates g/hr. NOx	30.343	Idling Vehicle Emissions for Passenger Cars, Light-Duty Trucks, and Heavy-Duty Trucks Emission Facts, EPA420-F-08-025, October 2008

4. Benefit Analysis

The method, analysis, and results for each Project benefit category are described in the following sections.

Safety Benefits

A key goal of the Project is to reduce the likelihood of fatalities, injuries, and property damage that result from crashes given the current road hazards. Through roadway safety and modernization, safety of the corridor is improved and provides better access to the area and region. The Project would result in safety benefits by modernizing the corridor through grade modification and the addition of passing and climbing lanes. This will improve motorist and emergency service transit and access along the corridor. The Project will also include a dedicated bridge separating wildlife and pedestrians from auto traffic.

Reduced Roadway Fatalities and Crashes

An important aspect of the Project is the implementation of roadway modernization. The proposed roadway will widen lanes with alternate climbing and passing lanes, widen and pave shoulders, and modify super elevations to improve flow.

NCDOT provided the crash history in the corridor across three segments over the past five years, which totaled 270 crashes. One incident in the crash history was a pedestrian. Crash modification factors (CMFs) were assigned by NCDOT by segment to reflect project conditions throughout the corridor. According to NCDOT guidance, the CMFs for a passing lane installation and shoulder widening are 0.75 and 0.86 respectively. Given the independence of the elements, CMFs were compounded to create a combined CMF of 0.645 in areas where there were multiple project aspects in a particular segment.[4] The combined CMF indicates an estimated reduction in crashes of 35.5% within the project area. NCDOT backup data and calculations are included in the included BCA workbook. The Project is estimated to eliminate 19 crashes annually over the 20-year analysis period; fatal, injury, and PDO crashes are valued using damages costs from the Guidance, as shown in Exhibit 3. ***In total, the Project results in roadway safety and modernization savings of $38.9 million, discounted at 7 percent.***

Emergency Services

Emergency services provide vital services to communities, such as fire response and emergency medical care. The ability for emergency services to respond quickly is essential to reducing damages and decreasing injuries and fatalities. With the addition of dynamic message boards, climbing lanes, and slope realignment, emergency response vehicles will be able to reach their destinations sooner.[5]

The FEMA method for estimating the loss of emergency services (fire and ambulance) was used to estimate the benefits of the Project.[6] The analysis assumes that the Project results in an improved emergency response time of 8 minutes per vehicle from the climbing lanes for portions[7] [8] of the populations of Graham, Swain, Cherokee, Jackson, and Macon Counties (17,084 population).[9] With the grade and ITS adjustments,

[4] NCDOT, "Carter responses on proposed improvements A-0009 grant". Excel Workbook
[5] Signal Systems. Online. NCDOT. https://www.ncdot.gov/initiatives-policies/Transportation/safety-mobility/its/Pages/signal-systems.aspx
[6] Presented in the USDOT's Benefit-Cost Analysis Guidance for Discretionary Grant Programs (January 2023) and described in FEMA's Benefit-Cost Analysis Re-Engineering (BCAR), Development of Standard Economic Values Version 6.0, December 2011
[7] 100% of Graham, 25% of Swain, and 5% each of Cherokee, Jackson, and Macon Counties are assumed to be served by emergency services through the corridor
[8] Topp, Andrew. STIP Project No. A-009C – Passing and Climbing Lane Justification Graham County, NC. Memorandum. October 23, 2020. Venture I. Raleigh, NC
[9] 2021 US Census Bureau. Online. https://www.census.gov/quickfacts/fact/table/grahamcountynorthcarolina/POP060210

the faster response time will allow emergency service providers to reduce the number of deaths from cardiac arrest and property losses due to fire in the service area. ***The emergency access benefit totals $11.1 million discounted at 7 percent.***

Wildlife Safety

The Project improves wildlife safety by providing a dedicated passageway for wildlife as well as wildlife crossing indicators. Historical data has confirmed wildlife encounters with motorists. Using the North Carolina Department of Transportation Animal Crash Data, annual incident data was estimated during the period of analysis for incidents within the Project area. The Colorado Department of Transportation (CDOT) has developed wildlife value estimates and a crash reduction factor of 0.87 to quantity impacts to wildlife located within the Project area. Using the annual wildlife incident data and the CDOT crash reduction factor, wildlife safety events were estimated as a benefit to the Project.[10] ***The wildlife savings associated with the wildlife bridge, however, is negligible.***

Economic Impacts, Freight Movement, and Job Creation

Travel Time Savings

The travel time savings for the Project result from improved mobility through passing and climbing lanes and through grade modification. Patriot Transportation Engineering, PLLC documented in their Passing Lane/ Climbing Lane technical memorandum that climbing and passing lanes improve mobility along the corridor allowing vehicles to efficiently pass slower moving vehicles.[11] These improvements save vehicles an average of 7 minutes per trip.

In addition to the grade modification and implementation of climbing and passing lanes, time saving is also realized through the signal coordination for lights in Graham County that are not already coordinated with the corridor. Users will save an average of 24 seconds per trip through the corridor using signal coordination. For both time saving opportunities, the analysis considers an conservative annual growth rate of 1.5% throughout the period of analysis based on historical AADT values and future projections from the years 2021 and 2045. Truck and auto value inputs are based on Guidance, as presented in Exhibit 3. ***The travel time savings for the Project total $54.9 million, discounted at 7 percent.***

Truck Operating Cost Savings

The Project results in efficiency for truck operators, resulting in operating cost savings. The annual operating cost saving is provided by the American Transportation Research Institute Operational Cost of Trucking 2022[12] and is estimated at $55.97 per hour (2021$). This estimate excludes the value of truck driver time, which is included in the Travel Time Savings benefit. ***The total truck operating cost savings is $5.6 million, discounted at 7 percent.***

Dynamic Message Signs (DMS) and Trailblazer Detour Delays Avoided

The Project results in avoided travel time for auto and truck drivers travelling along the corridor with the implementation of ITS through DMS and trailblazers. These systems will alert users in route to US 74 ahead of current landslides, accidents, and/or unforeseen maintenance delays. DMS and trailblazers reduce travel time by notifying commuters in advance, prior to them initiating their journey along the impacted segment

[10] Wild Animal Benefit-to-Cost Spreadsheet. CDOT. Online. https://codot.gov/programs/research/pdfs/2022/wildlife-prioritization/eswps-bca-instructions

[11] Topp, Andrew. STIP Project No. A-009C – Passing and Climbing Lane Justification Graham County, NC. Memorandum. October 23, 2020. Venture I. Raleigh, NC

[12] ATRI Operational Cost of Trucking 2022. Online. https://truckingresearch.org/wp-content/uploads/2022/08/ATRI-Operational-Cost-of-Trucking-2022.pdf

of US 74. On average, DMS and trailblazer detours save the traveler 4.52 hours, as estimated by the average maintenance times in the Traffic Incident Management System (TIMS) data provided by NCDOT.[13] Please refer to Exhibit 5 for a breakdown of the TIMS road closure summary data. The dataset includes events which occurred within the project corridor between the years 2018 through 2023. A total of 1,969 events were included in the analysis, with seven outlier events excluded due to disproportionate closure hours (over 1000 hours of closure per event). Events are sorted by year of occurrence and severity of the incident; road closed, road closed with detour, and road impassable. Auto and truck trips diverted reduce the wait time for maintenance and landslide delays, saving vehicle hours travelled (VHT). Operating cost and time savings were used to estimate the detour avoidance benefit for the Project based on those recommended by Guidance and presented in Exhibit 3. ***Detour cost savings resulting from DMS/trailblazers and maintenance delays total $93.8 million, discounted at 7 percent.***

Exhibit 4 – TIMS Closure Summary Data

Row Labels	Sum of Closure Hours	Count of Date Stamp	Hours per event
2018			
Road Closed	60.67	11	6
Road Impassable	289.93	4	72
2019			
Road Closed	50.25	16	3
Road Closed with Detour	92.83	5	19
2020			
Road Closed	341.07	37	9
Road Closed with Detour	5,077.87	14	363
Road Impassable	267.37	10	27
2021			
Road Closed	490.17	31	16
Road Closed with Detour	14,150.78	31	456
2022			
Road Closed	164.68	67	2
Road Closed with Detour	17.63	5	4
2023			
Road Closed	4.82	3	2
Road Closed with Detour	21.45	3	7
(blank)		1739	
Grand Total	21,029.52	1976	11
	8,908.02	**1969**	**4.52**

Agricultural Market Accessibility

The project increases accessibility for farmers and the agricultural industry located within the region. As of 2017, there were over one thousand farms in Graham, Swain, Cherokee, Jackson, and Macon Counties, many local and servicing the community.[14] With the Project improvements, farms in the region are supported and marginal transportation costs are saved through ease of accessibility. Additionally, tourists can also

[13] NCDOT. "TIMS.xlsx". Excel workbook

[14] County Summary, Crop and Livestock Cash Receipts by County, https://www.nass.usda.gov/Statistics_by_State/North_Carolina/Publications/Annual_Statistical_Bulletin/AgStat/Section06.pdf

access the farms and nearby National parks more reliably. This improved accessibility along the corridor reduces delays, shipping costs, and ultimately prices to the end users.[15]

The annual value of improvement was calculated by the estimated impacted expenses by county, the proportion of expenses related to travel, including indirect labor expenses, and the proportion of affected farmers. It was assumed that 75 percent of the total farms would be impacted. Assuming most of these farmers service the local community, transportation-related expenses were reduced by 9 percent with the Project elements. ***The total agricultural market accessibility benefit totals $36.4 million, discounted at 7 percent.***

Climate Change, Resiliency, and the Environment

The Project would result in environmental benefits by saving travel time from the slope and passing lane improvements and reduced idling from the implementation of the DMS and trailblazers.

Emissions Savings from Reduced Idling

Travel time savings for the Project result from improved mobility through the corridor by improving the slope with road modifications as well as passing and climbing lanes, saving vehicles an average of 7 minutes per trip in the corridor; the travel time savings for the slope and climbing lane modifications provided by TSGS Engineers in their Climbing and Passing Lane Documentation.[16] In addition, it is assumed that the ITS signal coordination for Robbinsville signals that are not already coordinated with the corridor will save each user approximately 24 seconds per trip.[17] Finally, the avoidance of long delays due to incidents on US 74 through the use of DMS and trailblazers will save users 4.5 hours on average. This travel time savings reduces emissions and the impacts to the community.

Emissions rates are based on grams per hour for autos and trucks, as found in Exhibit 3, and were valued for NO_x, $PM_{2.5}$, and CO_2 using economic damages per metric ton as found in Guidance. The value of CO_2 avoided was discounted at 3 percent. ***The emissions savings from reduced idling total $2.1 million, discounted at 7 percent and 3 percent for CO_2.***

Equity, Multimodal Options, and the Quality of Life

The Project allows for improved regional mobility and network connectivity, resulting in better access to the region for commuters, residents, and tourists through improved paratransit. This improved mobility enhances paratransit service times for users.

Travel Time Savings for Paratransit Users

The Project is estimated to reduce the travel time for the existing paratransit system users. The paratransit system is a demand response service that operates over 2,592 trips in the corridor annually. There are a total of nine vehicles that operate weekly along the corridor. The travel time savings from the slope modification and road widening will provide better access to those using the demand-response system. Corridor travel time improvements were estimated at a 7-minute improvement. Annual transit savings were estimated based on standard value of time rates included in the BCA Guidance. ***In total, the value of time saved for transit users from travel time savings is $0.4 million, discounted at 7 percent.***

[15] Millard, Chip. “From Farm to Table”. Federal Highway Administration. Summer 2019. Online. https://highways.dot.gov/ public-roads/summer-2019/farm-table

[16] Topp, Andrew. STIP Project No. A-009C – Passing and Climbing Lane Justification Graham County, NC. Memorandum. October 23, 2020. Venture I. Raleigh, NC

[17] Signal Systems. Online. NCDOT. https://www.ncdot.gov/initiatives-policies/Transportation/safety-mobility/its/Pages/signal-systems.aspx

Innovation Areas, Technology, Project Delivery and Financing

The Appalachian Trail is an attraction for residents and tourists travelling to and through Graham and Swain Counties. With the addition of the connected trail, pedestrians and wildlife can continue along the Appalachian Trail fluidly and with less risk of motor incidents. Parking accessibility was an inhibitor and the addition of two parking spaces will also encourage new tourists to the area for recreational activity.

Pedestrian Facility Improvements

The Project allows for greater access to the Appalachian Trail with a dedicated and widened bridge to allow for pedestrian and wildlife to cross the roadway. This pedestrian bridge allows users to continue along the trail, enhancing their recreational benefit and inducing recreational walking benefits. Guidance provides a benefit of $0.55 per user for the five-foot widening of the trail ***The pedestrian improvement benefit is negligible.***

Pedestrian Health and Recreation

The Project integrates pedestrian safety as well as mobility and accessibility into the regional transportation system. The Appalachian Trail is frequented by visitors daily. The corridor is currently limited by its current parking availability. The Project encourages visitors to utilize the trail by adding 33 percent more parking spaces. With greater multimodal access to the region's natural resources, it is anticipated that an increase in walking would occur. This shift provides health and recreation benefits for those additional pedestrians that would utilize the Project components. Guidance provides a benefit of $7.08 per induced walking trip for users aged 20-74. This analysis applies a 33% increase in walking trips due to the Project parking improvements. Baseline trail counts were provided by the Appalachian National Scenic Trail Conservancy using a 1.5% growth rate for users. In total, approximately 128,500 walking trips are estimated over the analysis period. ***The benefit of walking for health and recreation totals $0.2 million, discounted at 7 percent.***

State of Good Repair

Two state of good repair benefits result from the Project: the remaining value of the Project at the end of the analysis period and avoided recurring operating and maintenance costs of the existing roadway.

Roadway Operating and Maintenance Costs Avoided

Given the condition of the existing roadway, NCDOT has scheduled a series of activities along the corridor beginning in 2025 under the No Build. Costs and frequency of repairs were provided by NCDOT. This includes a full asset renewal update consisting of re-pavement ($7.2M), pipe and headwall replacement($1.8M), guardrail replacement and upgrade ($0.1M), and bridge replacement ($0.9M). The total cost for the full rehabilitation project in 2025 is estimated at $10.3 million. Additionally, subsequent activities are expected with re-pavement occurring every 15 years and the guardrail replacement and upgrade occurring every 20 years. Please refer to Exhibit 6 for the asset renewal summary. ***The roadway O&M costs avoided total $8.8 million, discounted at 7 percent.***

Exhibit 5 – **Full Asset Renewal – No Build (expected 2025)**

O&M Full Rehabilitation	Lifecycle	2022$	2021$
Pavement Rehabilitation	15	$ 7,661,078	$ 7,236,123
Pipe/Headwall Replacement	50	$ 1,934,714	$ 1,827,397
Guardrail Replacement/Upgrade	20	$ 130,968	$ 123,703
Bridge Replacement	75	$ 1,000,000	$ 944,531

Residual Value

Construction of the new roadway results in residual value because the Project elements have 25 useful years remaining after the end of the analysis period. The full value of the right of way acquired for the Project was also included in the residual analysis. It was assumed that 80 percent of the capital costs are for infrastructure. The remaining value of the roadway and right of way acquired was summed and discounted from the last year of the 20-year analysis period. ***The value of the remaining useful life for the Project discounted at 7 percent is $23.8 million.***

5. Cost Analysis

The Project has two cost components: the initial capital costs and annual ongoing operating and maintenance (O&M) costs.

Capital Costs

The capital costs for the Project include the costs for right of way, utilities, design, and construction. Exhibit 7 shows the capital costs in 2021 dollars.

Exhibit 7 – **Undiscounted Capital Costs—in 2021 Dollars**

Year	Cost
2022	$6,056,412
2023	$54,508,518
2024	$60,076,945
2025	$65,512,807
2026	$65,512,807
2027	$46,606,528
2028	$5,435,862
Total	**$324,622,000**

Source: NCDOT

The capital costs are applied over the individual project construction periods, beginning in 2022 and ending in 2028. Capital costs were estimated in 2022 dollars and converted to 2021 dollars using the deflator provided in Guidance, resulting in a total cost of $324.6 million (2022 dollars) and $303.7 million (2021 dollars). ***The total capital costs for the Project discounted at 7 percent are $244.9 million.***

Annual Operating and Maintenance Costs

The Project requires annual and periodic O&M expenditures to maintain the roadway, bridge, trail, signals, and pavement. O&M estimates for the Build scenario were provided by NCDOT and is estimated at $48,000 in the No Build and $77,000 in the Build, resulting in a net increase in O&M for the pavement. Periodic renewal costs avoided are described in the Roadway Operating and Maintenance Costs Avoided section. ***The Build O&M cost over the period of analysis is $1.3 million, discounted at 7 percent. (This is included in the Benefits total as a disbenefit to the Project.)***

6. BCA Results

The analysis results in a total Project Benefit-Cost Ratio (BCR) of 1.13 when discounted at a rate of 7 percent. Exhibit 8 displays a summary of the BCA results for the total Project.

Exhibit 8 – BCA Results for the Project

Analysis Period: (20 years)	Total Project 7% Discount Rate 2028-2048
Costs (2021$M)	
Capital Cost	$244.9
Total Costs	***$244.9***
Safety Benefits	
Reduced Roadway Fatalities and Crashes	$38.9
Emergency Services	$11.1
Wildlife Safety	Negligible
Subtotal	*$50.0*
Economic Impacts, Freight Movement, and Job Creation	
Auto Travel Time Savings	$49.0
Truck Travel Time Savings	$3.2
Truck Operating Savings	$5.6
Signal Coordination Time Savings	$2.7
Maintenance Detour Delays Avoided	$11.0
DMS/Trailblazers Detour Delays Avoided	$82.9
Agricultural Market Accessibility Benefit	$36.4
Sub-Total	*$190.7*
Climate Change, Resiliency, and the Environment	
Emissions Savings	$2.1
Sub-Total	*$2.1*
Equity, Multimodal Options, and Quality of Life	
Paratransit Travel Time Savings	$0.4
Sub-Total	*$0.4*
Innovation Areas: Technology, Project Delivery, and Financing	
Resident and Visitor Recreation	$0.2
Sub-Total	*$0.2*
State of Good Repair	
Net Operating & Maintenance Cost Savings	$8.8
Residual Value	$23.8
Sub-Total	*$32.6*
Total Benefits	***$275.8***
Results	
Net Present Value (2021 $M)	$30.9
Benefit-Cost Ratio	1.13

Appendix A List of Supporting Documents

AECOM, “A-0009 Benefit Cost Analysis.xlsx” Excel Workbook

NCDOT, “Carter responses on proposed improvements A-0009 grant”. Excel Workbook

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Wild Animal Benefit-to-Cost Spreadsheet. Colorado Department of Transportation. Online. https://codot.gov/programs/research/pdfs/2022/wildlife-prioritization/eswps-bca-instructions