

Technical Memorandum: Benefit-Cost Analysis of the iBRAGG Project

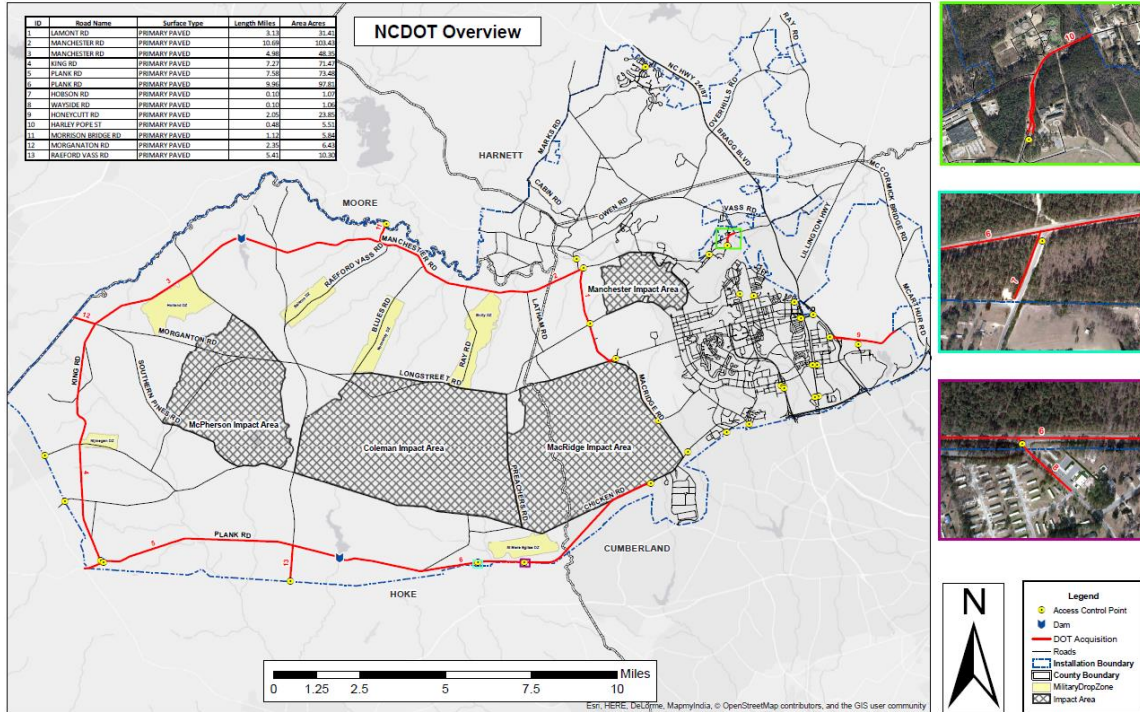
Date: July 15, 2019

Subject: Benefit-Cost Analysis for the iBRAGG Project

Project Description

The *improving Bragg Roads and Access for Greater Growth* Project (“iBRAGG” or “the Project” hereafter) will facilitate the rationalization of roadway maintenance in the vicinity of Fort Bragg, yielding long-term savings and improved safety and design for all travelers in the vicinity of Fort Bragg. The iBRAGG Project will reconstruct a set of roads located on the military reservation, but outside the gates of the secure area, as illustrated in Figure 1, to bring them back to a state of good repair. These roads were originally constructed by the military staff posted at the Fort and were intended for training use; in their current state, they do not meet North Carolina Department of Transportation (NCDOT) design specifications. Once the roads are repaired and in good condition, they will be transferred to NCDOT for operation and maintenance according to a Memorandum of Agreement signed by The U.S. Army Garrison (USAG) Fort Bragg North Carolina and the NCDOT. As part of the agreement, Fort Bragg will petition the NCDOT to add the roads to the State Highway System. This addition will be accomplished in accordance with NCDOT road addition procedures, which includes approval by the NCDOT Board of Transportation. Bringing the roads into a state of good repair and consistent with current state standards is a condition of making the transfer.

Figure 1 – Roads to be Transferred to NCDOT



Source: NCDOT and Fort Bragg

In addition to the Fort Bragg Ring Roads, a second project on Wayside Road will be completed. Wayside Road (NCDOT project U-5753) will be widened from a two- to four-lane divided facility with a raised median. Wayside Road connects Plank Road on the southern border of Fort Bragg to US 401 in Fayetteville.

Transportation Challenge

Fort Bragg is a critical military facility, as well as an economic anchor for the Fayetteville metropolitan area. Over time, these two large economic centers have become more integrated through a shared labor pool, contracting, and coordination of public services and activities. As a result, the roads now carry more traffic than envisioned when they were constructed as they are used by the general public for non-base related travel, as well as for traffic to and from the base. Cut-through traffic, travel for which the base is neither an origin nor a destination, has grown in recent years as travelers use the surrounding roads to avoid nearby congested arterials. An estimate of this non-base traffic was developed for two nearby intersections. For both intersections, the cut-through volume is shown with the cut-through percentage of the intersection traffic.

Table 1 – Estimated Non-Base Traffic Using Adjacent Roads (2019)

Intersection	AM	PM	13-hours	Movements Considered Cut-Through
Wayside Rd	357	335	3253	Left Out of and Right In to Wayside
Morrison	35 (3%)	42 (4%)	327 (2%)	Right Out of and Left In to Morrison Bridge

As a consequence, a rising volume of travel comprised of base-related and non-base related trips are being made on poorly maintained roads that do not meet NCDOT’s current standards. The transfer of maintenance responsibility to NCDOT shifts this activity to an agency that is better able to maintain the roads to a higher quality. Road quality in this instance is measured primarily in terms of safer design and smoother pavement that results in less wear and tear on vehicles.

A map of the ring roads and Wayside Road is shown in

Figure 2 followed by an impact matrix in Table 2 describing the Project’s benefits.

Figure 2– Project Elements

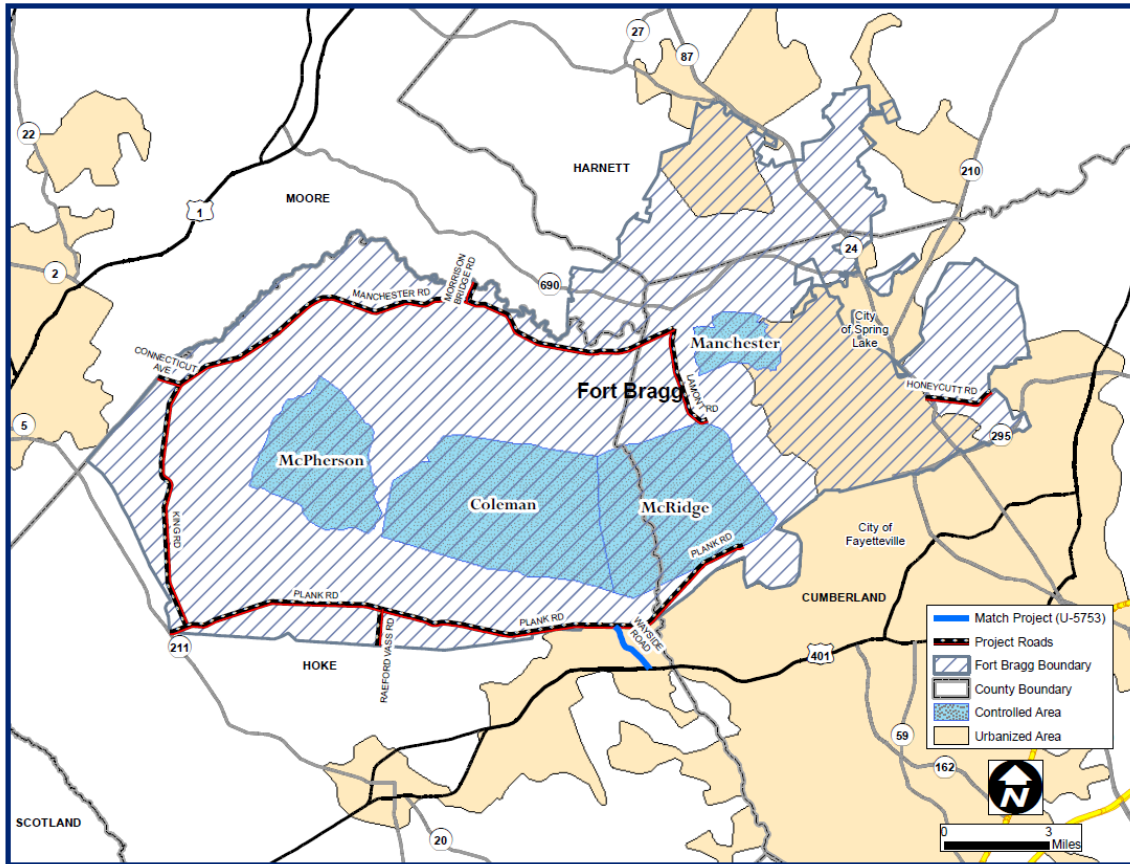


Table 2 – Project Matrix

Current Status/Baseline & Problem to be Addressed	Change to Baseline or Alternatives	Types of Impacts	Affected Population	Economic Benefit (Net Present Values, \$2017 M) Discounted at 7%	Page Reference in BCA
Existing roads around Fort Bragg are in a state of disrepair, resulting in vehicle wear and tear, crashes, and ongoing maintenance that is performed by the military instead of NCDOT.	The ring roads will be brought up to a state of good repair and will be able to be handed over and maintained by NCDOT. The improved roads will save vehicle maintenance costs, improve travel speeds and safety, save truck operating time, avoid future costs of flooding, and save emissions. In addition, fiber will be included to bring high-speed internet to rural areas.	Safety			
		Reduced Highway Fatalities and Crashes	Roadway users	\$26.2	7
Wayside Road needs additional capacity to serve the increasing volumes of traffic.	Increasing capacity on Wayside Road improves safety and reduces travel time, truck operating costs, and emissions.	Economic Competitiveness			
		Delays During Construction	Auto and truck roadway users	-\$6.1	8
		Travel Time Savings	Auto and truck roadway users	\$39.2	9
		Truck Operating Savings	Truck roadway users	\$1.9	10
		Vehicle Maintenance Savings	Auto roadway users	\$5.5	10
		State of Good Repair			
		Residual Value	North Carolina taxpayers, NCDOT	\$1.6	11
Resilience Repair Cost Savings	North Carolina taxpayers, NCDOT	\$3.3	11		
Environmental Sustainability					
Emissions Savings (auto)	All users and nonusers	\$0.1	12		
Emissions Savings (truck)	All users and nonusers	\$0.0	12		
Quality of Life					
Fiber Benefit	Residents within the Project counties	\$7.4	13		

Introduction

This technical memorandum estimates the long-term benefits associated with the Project. The long-term benefits presented relate to five goals identified in the BUILD 2019 Notice of Funding Opportunity (NOFO):¹ Safety, Economic Competitiveness, State of Good Repair, Environmental Sustainability, and Quality of Life. The results are the discounted streams of anticipated benefits and costs and the Benefit-Cost Ratios for the two individual Project components as well as the Project as a whole.

The Project described in this application would support the region's economy over the long-term by providing the workforce and residents of North Carolina with improved roadway facilities to and around Fort Bragg, generating travel time savings, auto and truck emissions reductions, reducing the likelihood of accidents, and reducing wear and tear on vehicles from poorly maintained roads.

The balance of this discussion describes the assumptions and methods used to develop the benefit-cost analysis and estimate the value of the long-term benefits generated by the investment. As directed in the BUILD guidance, the benefits of the capital investment have been estimated over a 30-year analysis horizon. The last element of the Project's construction would be completed in 2024, and an overall benefits period of 2024-2054 was used.

Benefits are estimated in accordance with guidance provided by U.S. Department of Transportation (USDOT) for benefit-cost analysis. If no USDOT guidance was available, the Project team consulted industry research for the best practice and information on which to base the assumptions and methodology.

The benefits quantified in the benefit-cost analysis are described in the following pages in 2017 dollars discounted to 2019. Benefits for each Project element are described within the benefit categories.

Analysis Assumptions

A list of assumptions for the Project is provided in the BCA workbook (see Inputs tab in the file BCA.xlsx) as well as in Table 3.

Table 3- BCA Calculation Inputs

Input	Value	Source
General		
Discount Rate	7%	2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs
Discount Year	2019	2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs
Dollar Year	2017	2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs
Construction Start	2021	
Construction End	2023	
Operations Start (Ring Road)	2024	
Operations Start (U-5753)	2025	
Actual annual likelihood of the "500-year storm" like Matthew Note that Matthew's intensity was considered a 500-year	5%	Floyd (1999), Matthew (2016), and Florence (2018) can be considered 500-year storms that occurred within 20 years. Based on this history, conservatively assuming one storm of this caliber will occur every 20 years moving forward.

¹ See BUILD 2019 Notice of Funding Opportunity, <https://www.transportation.gov/sites/dot.gov/files/docs/subdoc/391/fy-2019-build-nofo-fr.pdf>

storm, but its actual frequency is more often than that.		
Deflator	See "Deflator" Sheet	https://www.whitehouse.gov/wp-content/uploads/2019/03/hist10z1-fy2020.xlsx
Auto Occupancy	1.68	2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs
Annual O&M per road mile after reconstruction, 2019\$	\$26,500	NCDOT Division 8
Annual O&M per road mile after reconstruction, 2017\$	\$25,422	NCDOT Division 8, adjusted by GDP Deflator
Miles of road	46.65	NCDOT, Fort Bragg "Training Roads Revised Mileage"
Current annual O&M of facilities (Lamont, Manchester, King, Plank, and Chicken Roads)	\$150,000	Fort Bragg
Annual O&M Fiber (2017\$)	\$50,000	AECOM estimate
Annualization Factor	260	Assumes weekday travel
ADT annual growth	1.5%	NCDOT and Fort Bragg
Average speed increase assumed with new roads	5.0%	Engineering judgement
Truck share on U-5753	3.0%	NCDOT
WTP for Fiber per HH, once per year (2017\$)	\$10.37	Peterson, Richard, "Paying for Speed: Measuring Willingness to Pay in U.S. Broadband Markets," University of Colorado, October 17, 2017.
Economic Vitality		
Value of Time All Purposes, 2017\$	\$16.10	2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs
Value of Time Truck, 2017\$	\$28.60	2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs
Truck Operating Costs per hour (2017\$)	\$42.70	Table 9 ATRI Operational Cost of Trucking 2018. Includes fuel, oil, truck/trailer lease, repair, maintenance, driver benefits, tires, and insurance. Excludes driver time (valued in travel time savings); http://atri-online.org/wp-content/uploads/2018/10/ATRI-Operational-Costs-of-Trucking-2018.pdf
Vehicle Operating Cost per mile (2017\$), auto	\$0.39	2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs
Vehicle Operating Cost per mile (2017\$), truck	\$0.90	2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs
Safety		
O- No injury (2017\$)	\$3,200	2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs
C - possible injury (2017\$)	\$63,900	2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs
B - non-incapacitating injury (2017\$)	\$125,000	2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs
A - incapacitating (2017\$)	\$459,100	2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs
K - killed (2017\$)	\$9,600,000	2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs
U - Injured (severity unknown) (2017\$)	\$174,000	2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs
# Accidents Reported (unknown if injured) (2017\$)	\$132,200	2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs
Crash Reduction Factor (%) for adding a raised median	60%	NCDOT
Environmental		
VOC Value of Emissions (2017\$) per short ton	\$2,000	2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs

NOx Value of Emissions (2017\$) per short ton	\$8,300	2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs
PM Value of Emissions (2017\$) per short ton	\$377,800	2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs
SO2 Value of Emissions (2017\$) per short ton	\$48,900	2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs
Passenger Car Gasoline Consumption Per mile	0.04149	http://www.epa.gov/otaq/consumer/420f08024.pdf
Short tons per Metric Ton	1.1015	2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs
LDGV Emissions Rates g/hr VOC	2.683	nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P100EVXV.TXT
LDGV Emissions Rates g/hr NOX	3.515	nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P100EVXV.TXT
Truck Emissions Rate g per hour VOC (average of 8a and 8b trucks)	3.868	Source: https://www3.epa.gov/otaq/consumer/420f08025.pdf , Class 8 trucks include long-haul semi-tractor trailer rigs ranging from 33,001 lbs to >60,000 lbs
Truck Emissions Rate g per hour Nox (average of 8a and 8b trucks)	39.0515	Source: https://www3.epa.gov/otaq/consumer/420f08025.pdf , Class 8 trucks include long-haul semi-tractor trailer rigs ranging from 33,001 lbs to >60,000 lbs
Truck Emissions Rate g per hour PM _{2.5} (average of 8a and 8b trucks)	1.092	Source: https://www3.epa.gov/otaq/consumer/420f08025.pdf , Class 8 trucks include long-haul semi-tractor trailer rigs ranging from 33,001 lbs to >60,000 lbs
Social Cost of Carbon		
	2017\$ per metric ton	
2017	\$1.00	2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs
2020	\$1.00	2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs
2025	\$1.00	2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs
2030	\$1.00	2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs
2035	\$2.00	2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs
2040	\$2.00	2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs
2045	\$2.00	2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs
2050	\$2.00	2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs

Benefits

Safety

The Project elements will result in a safer facility by reducing the number of crashes and resulting fatalities, injuries, and property damage. The monetization of these safety benefits are described in this section.

The crash reduction factors were valued based on the KABCO score. KABCO refers to the letters used to designate five levels of crash severity used by police at a crash scene, and each type of injury has a different associated economic cost. The costs of each injury are shown in Table 3.

Reduced Highway Fatalities and Crashes

Fort Bragg Ring Roads

Based on crash reduction factors estimated by an AECOM safety analysis that considered the current geometry of the facilities compared to the proposed improved geometry, the Project is expected to reduce crashes by 13.4 per year. The crash reductions were held constant throughout the analysis period and conservatively assume one person and vehicle is involved in each crash.

A Crash Reduction Factor (CRF) of 20 percent was used in the analysis. The crashes avoided annually are shown in Table 4 and were valued based on the KABCO score as shown in Table 3.

Table 4 – Annual Fort Bragg Ring Road Crash Reduction Summary by Severity

	Crash Reduction Summary (crashes per year)				
	Crash Severity				
	K	A	B	C	PDO
Total Reduced	0.057	0.400	1.543	0.629	10.857

Source: AECOM safety analysis.

For more information, see Supplemental Materials.

Note: Conservatively assumes one person and one vehicle per crash.

The total reduction in fatalities and crashes was valued at \$9.5 million, discounted at 7 percent.

Wayside Road (U-5753)

Wayside Road has a five-year historical crash rate of 32.2 crashes per year. A CRF of 60 percent for the introduction of a raised median in a rural area was used to estimate the crash reduction associated with the Project.² The crashes avoided annually are shown in Table 4 and were valued based on the KABCO score as shown in Table 3. These crash reductions were held constant throughout the analysis period and conservatively assume one person and vehicle is involved in each crash.

Table 5 – Annual Wayside Road Crash Reduction Summary by Severity

	Crash Reduction Summary (crashes per year)				
	Crash Severity				
	K	A	B	C	PDO*
Total Reduced	0.12	0.12	1.56	7.08	10.44

Source: NCDOT

Note: conservatively assumes one person and one vehicle per crash.

The total reduction in fatalities and crashes was valued at \$16.7 million, discounted at 7 percent.

Economic Competitiveness

The Project includes a number of economic competitiveness benefits, including travel time savings, truck operating savings, and vehicle maintenance savings. The disbenefits of delays during construction are also quantified and described in this section.

Delays During Construction

Fort Bragg Ring Roads

The analysis assumes that construction delays on the Fort Bragg ring roads would result from 20 mph lower average speeds for three years and that detours of approximately 5 miles will also be incurred for two months per construction year as construction is phased around the base.

Construction delays for the Fort Bragg Ring Roads total \$4.8 million discounted at 7 percent.

² Provided by NCDOT

Wayside Road (U-5753)

Construction delays on Wayside Road would be minimal, with an average speed decrease of 5 mph for three years over a half-mile construction zone. NCDOT notes that two-way traffic will be maintained during construction with occasional lane closures about overall minimal impacts to daily traffic.

Construction delays for Wayside Road total \$1.3 million discounted at 7 percent.

Travel Time Savings

Fort Bragg Ring Roads

With the upgrade of the Fort Bragg Ring Roads to a state of good repair, vehicles can safely travel at a slightly faster speed. As noted by Fort Bragg and NCDOT, drivers already speed on the ring roads, creating dangerous conditions for themselves and other drivers, particularly when large equipment use the roads.

To estimate the current average speeds on the roads, data collected in January 2018 on Lamont Road near McKellars Road were analyzed and showed that vehicles traveled at an average of 126 percent of the posted speed limit. This average speed increase was assumed for all segments of the Project. It is assumed that travelers could safely travel at 4 percent higher speeds in the Build than No Build.

Comparing the segment lengths, traffic volumes, current average speeds and projected average speeds with the Project constructed results in travel time savings with the Project. The speed limits, current average speeds, Build average speeds, AADT, truck share, and segment length are summarized in Table 6.

Table 6 – Fort Bragg Ring Road Traffic Characteristics by Segment

Segment ID	Route Name	Posted Speed Limit (mph)	Current Average Speed	BUILD Average Speed**	AADT	Truck %	Segment Length* (miles)
1	Lamont Road	35	44	45.76	7,200	4%	3.29
2	Manchester Road	55	69	71.9	7,100	4%	4.96
3	Manchester Road	55	69	71.9	3,900	5%	10.92
4	King Road	55	69	71.9	2,300	4%	7.23
5	Plank Road	55	69	71.9	3,000	3%	8.33
6	Plank Road	55	69	71.9	11,000	3%	9.63
7	Honeycutt Road*	45	57	58.8	14,000	2%	2.05
8	Morrison Bridge Road	45	57	58.8	3,500	4%	0.59
9	Morganton Road	50	63	65.4	1,700	4%	0.65
10	Raeford Vass Road	35	44	45.8	2,300	3%	1.05
					5,600		48.7

*based on NCDOT estimate; includes roadway length of Honeycutt Rd estimated separately **assumes average speeds can safely increase by 4%

Based on the truck percentages by segment, travel time savings was apportioned to autos and trucks. Autos were also factored by the auto occupancy rate of 1.68 per BCA guidance. The value of time used for auto passengers is \$16.10 per hour representing all travel purposes. Trucks are valued at \$28.60 per hour. The traffic volumes are expected to grow at 1.5 percent per year, according to Fort Bragg and NCDOT.

The travel time savings amounts to \$13.6 million discounted at 7 percent.

Wayside Road (U-5753)

The travel time savings on Wayside Road were provided by NCDOT. According to the U-5737 Community Characteristics Report from December 2016, the travel times along the Project corridor are likely to decrease by two minutes. The analysis assumes a conservative 1.5 minutes of travel time savings per vehicle for existing truck (3 percent) and auto traffic. Based on traffic volumes provided by NCDOT and an annual growth rate of 0.8 percent per year, the total travel time savings was estimated by valuing auto time at \$16.10 per hour and truck time at \$28.60 per hour. Autos were also factored by the auto occupancy rate of 1.68.

The travel time savings on Wayside Road total to \$25.6 million discounted at 7 percent.

Truck Operating Savings

Fort Bragg Ring Roads

The travel time savings on the Fort Bragg Ring Roads result in operating cost savings for trucks. The operating cost per hour for trucks was found in the ATRI Operational Cost of Trucking,³ which is inclusive of fuel, oil, truck/trailer lease, maintenance, driver benefits, tires, and insurance and totals \$42.70 per hour. Driver time was excluded because it was already included in the Travel Time Savings benefit. Multiplying the daily travel time savings by the truck percentages by segment as shown in Table 6, annualizing by 260, and multiplying by the truck operating cost per hour results in the truck operating savings.

The total operating time savings for trucks on the Fort Bragg Ring Roads amounts to \$721,000 discounted at 7 percent.

Wayside Road (U-5753)

The travel time savings on Wayside Road result in operating cost savings for trucks. The operating cost per hour for trucks as described previously totals \$42.70 per hour. Driver time was excluded because it was already included in the Travel Time Savings benefit. Multiplying the daily travel time savings by the truck percentage (3 percent), annualizing by 260, and multiplying by the truck operating cost per hour results in the truck operating savings.

The total operating time savings for trucks on Wayside Road amounts to \$1.2 million discounted at 7 percent.

Vehicle Maintenance Savings

Fort Bragg Ring Roads

The Project will improve the quality of the roadways around Fort Bragg, resulting in savings for drivers whose vehicles get damaged by the rough roads without the Project.

To estimate the cost of wear and tear on vehicles avoided by improving the quality of the pavement, the analysis made the following assumptions based on the research literature.

The typical trip length in the corridor is 11.7 miles, or approximately a quarter of the improved corridor length, as many drivers use the ring roads as a cut through between Fayetteville and Southern Pines, in addition to shorter local trips. The excess cost per mile of driving in poor conditions is 3 cents per mile. TRIP, a national transportation research group, reports that drivers

³ Table 9 ATRI Operational Cost of Trucking 2018. Includes fuel, oil, truck/trailer lease, repair, maintenance, driver benefits, tires, and insurance.

in the Fayetteville area pay an average of \$383 annually due to poor roads.⁴ This value was divided by the average number of vehicle miles traveled per registered vehicle in North Carolina, according to FHWA statistics, of 14,384. The cost avoided by improving the roads is thus the annual traffic volume (number of trips) in the corridor multiplied by 11.7 miles per trip and \$0.03 per mile.

When discounted at 7 percent, this stream of benefits yields \$5.5 million in vehicle maintenance savings.

Wayside Road (U-5753)

No vehicle maintenance savings are estimated for the Wayside Road Project.

State of Good Repair

Residual Value

Fort Bragg Ring Roads

Construction of the new roadway would have residual value after the end of the 30-year analysis period, because the useful life of certain Project elements is longer than 30 years. Highways and streets have a useful life of 60 years, sewer systems (utilities) also have a useful life of 60 years,⁵ and land (right of way) does not depreciate. It was assumed that 80 percent of the highway and utilities costs are non-labor expenses and they depreciate using straight-line depreciation. The value of land was added to the remaining value of the other assets and discounted from the final analysis year (2053).

The residual value for the Fort Bragg Ring Roads discounted at 7 percent is \$0.9 million.

Wayside Road (U-5753)

Construction of the new roadway would have residual value after the end of the 30-year analysis period, because the useful life of these elements is longer than 30 years. Highways and streets and sewer systems (utilities) have useful lives of 60 years and land does not depreciate. It was assumed that 80 percent of the highway and utilities costs are non-labor expenses and they depreciate using straight-line depreciation. The value of land was added to the remaining value of the other assets and discounted from the final analysis year (2054).

The residual value for the Fort Bragg Ring Roads discounted at 7 percent is \$0.6 million.

Resilience Repair Cost Savings

Fort Bragg Ring Roads

During Hurricane Matthew and the heavy rain event the week prior, the training area roads of Manchester, King, Plank, and Chicken suffered damage ranging from sink holes to total wash outs. Following these storms in September and October 2016, Manchester Road was closed to traffic and officials diverted traffic via King Rd to Plank Rd to Chicken Rd. Fort Bragg funded \$7.0 million in repairs to these roads as a result of the Hurricane Matthew and the preceding rain event. Due to the work performed after Hurricane Matthew, no damage was reported on these roads following Hurricane Florence.

⁴ Pavement Conditions and Extra Vehicle Operating Costs for Urban Areas of 500K or More, Report: http://www.tripnet.org/docs/Urban_Roads_TRIP_Report_October_2018.pdf Appendices: http://www.tripnet.org/docs/Urban_Roads_TRIP_Report_Appendices_October_2018.pdf

⁵ Bureau of Economic Analysis Rate of Depreciation, Service Lives, Declining-Balance Rates, and Hulten-Wyckoff Categories, http://www.bea.gov/scb/account_articles/national/wlth2594/tableC.htm

Assuming a 5.0% annual likelihood of similar repairs following a storm such as Hurricane Floyd, Matthew, or Florence, which would no longer be necessary after the Project is built, the total resilience repair costs avoided total \$3.3 million when discounted at 7 percent.

Wayside Road (U-5753)

No resilience repair cost savings are estimated for the Wayside Road Project.

Environmental Sustainability

Auto Emissions Savings

Fort Bragg Ring Roads

Improvements to the Fort Bragg Ring Roads result in travel time savings for users and therefore reduced emissions. Annual volatile organic compounds (VOC) and nitrogen oxides (NO_x) savings were estimated based on rates found from the EPA.⁶ The tons of reduced emissions were monetized using the recommended value of emissions from BUILD 2019 guidance as shown in Table 3. The travel time savings were used to estimate emissions savings.

In total, the Fort Bragg Ring Roads result in auto emissions savings of \$31,000, discounted at 7 percent.

Wayside Road (U-5753)

Improvements to Wayside Road results in travel time savings for users and therefore reduced emissions. Annual VOC and NO_x savings were estimated based on rates found from the EPA and monetized as described for the Fort Bragg Ring Roads. The travel time savings were used to estimate emissions savings.

In total, the Wayside Road Project results in auto emissions savings of \$35,000, discounted at 7 percent.

Truck Emissions Savings

Fort Bragg Ring Roads

Trucks are also expected to experience travel time savings when the Project is operational. Based on emissions rates per idling hour as found in EPA guidance,⁷ the tons of VOC, NO_x, and particulate matter with a diameter less than 2.5 micrometers (PM_{2.5}) were estimated. The tons of reduced emissions were monetized using the recommended value of emissions from BUILD 2019 guidance as shown in Table 3.

In total, truck emissions savings total \$14,000, discounted at 7 percent.

Wayside Road (U-5753)

Trucks are also expected to experience travel time savings when the Project is operational. Based on emissions rates per idling hour, the tons of VOC, NO_x, and PM_{2.5} were estimated. The tons of reduced emissions were monetized using the recommended value of emissions as shown in Table 3.

In total, truck emissions savings total \$23,000, discounted at 7 percent.

⁶ EPA, Idling Vehicle Emissions for Passenger Cars, Light-Duty Trucks, and Heavy-Duty Trucks, EPA420=F-8-025, October 2008, nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P100EVXV.TXT

⁷ EPA, Idling Vehicle Emissions for Passenger Cars, Light-Duty Trucks, and Heavy-Duty Trucks, EPA420=F-8-025, October 2008, nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P100EVXV.TXT. Class 8 trucks include long-haul semi-tractor trailer rigs ranging from 33,001 lbs to >60,000 lbs

Quality of Life

Fiber Benefits

Fort Bragg Ring Roads

The Project utilizes transportation infrastructure investment to accomplish more than just transportation improvements. There is a digital divide between rural and urban areas in terms of access to the high-speed broadband and communications capabilities needed to run modern applications. Figure 3 highlights the geographic pattern of high-speed connectivity in the state and the large gaps in service in the Project area. This lack of access hinders economic development in small communities, limits agricultural access to applications that use big data to monitor and assess microclimate and yield data over large areas, and restricts educational opportunities. NCDOT will be working with its State Agency partners to utilize this new communications backbone to deliver these types of benefits to rural areas.

Figure 3 - Broadband Availability at 25 MBPS Download Speeds



Source: Connecting North Carolina, State Broadband Plan, 2016

The installation of fiber would allow for more accurate use of apps such as Waze and others that allow users to anticipate traffic conditions and plan ahead appropriately. The transportation system is therefore used more efficiently. In addition, emergency services, evacuation, public safety, and roadside safety can all be improved with better broadband connectivity.

The Project will install fiber along the Fort Bragg Ring Roads, allowing for faster internet access for the areas outside of Fayetteville including Raeford and Southern Pines, as well as the western portion of Fort Bragg. This benefit is quantified using a willingness to pay (WTP) methodology. As found in the literature,⁸ the value of an increase in broadband internet up to at least 4 megabytes per second (MBPS) is worth \$10.37. This is assumed to be per household and is conservative because a typical internet speed is about 25 MBPS and therefore would be valued higher. It is assumed that half of the households within the counties of Hoke, Harnett, and Moore (estimated from Census 2010 data)⁹ would be willing to pay once per year for the improved internet connection. The estimated county households increase annually based on historical population growth from the NC Office of State Budget and Management (OSBM).¹⁰

⁸ Peterson, Richard, "Paying for Speed: Measuring Willingness to Pay in U.S. Broadband Markets," University of Colorado, October 17, 2017. See "WTP_Fiber.pdf" in the Supplemental Materials

⁹ Excluded county: Cumberland

¹⁰ NC Management and Budget, https://files.nc.gov/ncosbm/demog/countygrowth_cert_2016.html

The total fiber benefit for the Fort Bragg Ring Roads amounts to \$7.4 million discounted at 7 percent.

Wayside Road (U-5753)

Fiber is not installed as part of the Wayside Road Project.

Costs

Capital Costs

Fort Bragg Ring Roads

The capital costs for the Fort Bragg Ring Roads Project include the costs for final design, right of way, utilities, construction, and installation of fiber. The costs of each Project element are shown in Table 7.

Table 7 – Fort Bragg Ring Roads Construction Costs, in 2019 dollars

	2019\$
PE	\$2,499,346
ROW	\$50,000
Utility Relocation*	\$2,882,750
Construction	\$21,455,864
Total Cost	\$26,887,960

Source: NCDOT

*Note Utility Relocation includes Fiber

The capital costs are applied over a three year construction period, beginning in 2021 and ending in 2023.

The capital costs were converted to 2017 dollars and discounted at 7 percent; the total capital costs for the Fort Bragg Ring Roads are \$20.4 million.

Wayside Road

The capital costs for the Wayside Road Project include the costs for final design, right of way, utilities, and construction. The costs of each Project element are shown in Table 8.

Table 8 – Wayside Road Construction Costs, in 2019 dollars

	2019\$
PE	\$1,500,000
ROW	\$2,178,000
Utility Relocation*	\$261,000
Construction	\$12,198,000
Total Cost	\$16,137,000

Source: NCDOT

The capital costs are applied over a six year construction period, beginning in 2019 and ending in 2024.

The capital costs were converted to 2017 dollars and discounted at 7 percent; the total capital costs for Wayside Road are \$12.3 million.

Operating and Maintenance Costs

Fort Bragg Ring Roads

The Project requires annual and periodic O&M costs to keep the roads and fiber operating in a state of good repair. Maintenance begins in 2024, as the first full year of operation, and the O&M costs are the incremental difference between the current O&M costs compared to the costs to maintain the upgraded segments. The current O&M is \$143,900 per year and in the future is estimated at \$1.2 million per year, resulting in a net cost of \$1.1 million per year in 2017 dollars. Fiber is assumed to require minimal maintenance annually, estimated at \$50,000 per year.

The total O&M costs over the analysis period discounted at 7 percent is \$10.3 million.

Wayside Road

The Project requires annual and periodic O&M costs to keep the road operating in a state of good repair. Maintenance begins in 2025, as the first full year of operation, and the O&M costs are the incremental difference between the current O&M costs compared to the costs to maintain the upgraded segments. The current O&M is \$42,400 per year and in the future is estimated at \$84,800 per year, resulting in a net cost of \$42,400 per year.

The total O&M costs over the analysis period discounted at 7 percent is \$401,000.

Summary

Table 9 summarizes the discounted value of the benefits and costs discussed in this memorandum for the total Project and its two elements separately. Taken in total and using a 7 percent discount rate, the Project provides \$68.4 million dollars of benefits over the 31-year total Project analysis period. Compared to a similarly discounted cost estimate, the Benefit Cost Ratio (BCR) for the Project is 2.09, a solid return on these critical investments. The net benefits total \$35.7 million.

Each element of the Project also has a BCR greater than 1.0, with the Fort Bragg Ring Roads having a BCR of 1.27 and Wayside Road having a BCR of 3.46. Table 10 displays the summary table for the Fort Bragg Ring Roads and Table 11 shows results for Wayside Road.

Table 9 – Total Project Benefit-Cost Analysis (2024-2054 in 2017 \$M)

	Discounted at 7%
Costs	
Capital Costs	\$32.7
Total Costs	\$32.7
Benefits	
Safety	
Reduced Highway Fatalities and Crashes	\$26.2
Sub-Total Safety Benefits	\$26.2
Economic Competitiveness	
Delays During Construction	-\$6.1
Travel Time Savings	\$39.2
Truck Operating Savings	\$1.9
Vehicle Maintenance Savings	\$5.5
Sub-Total Economic Competitiveness	\$40.5
State of Good Repair	
Residual Value	\$1.6
Resilience Repair Cost Savings	\$3.3
Sub-Total State of Good Repair	\$4.9
Environmental Sustainability	
Emissions Savings (auto)	\$0.07
Emissions Savings (truck)	\$0.04
Sub-Total Environmental Sustainability	\$0.1
Quality of Life	
Fiber Benefit	\$7.4
Sub-Total Quality of Life	\$7.4
O&M Costs	-\$10.7
Net O&M	-\$10.7
Total Benefits	\$68.4
BC Ratio	2.09
Net Benefits	\$35.7

Table 10 – Fort Bragg Ring Roads Project Benefit-Cost Analysis (2024-2053 in 2017 \$M)

	Discounted at 7%
Costs	
Capital Costs	\$20.4
Total Costs	\$20.4
Benefits	
Safety	
Reduced Highway Fatalities and Crashes	\$9.5
Sub-Total Safety Benefits	\$9.5
Economic Competitiveness	
Delays During Construction	-\$4.8
Travel Time Savings	\$13.6
Truck Operating Savings	\$0.7
Vehicle Maintenance Savings	\$5.5
Sub-Total Economic Competitiveness	\$15.1
State of Good Repair	
Residual Value	\$0.9
Resilience Repair Cost Savings	\$3.3
Sub-Total State of Good Repair	\$4.3
Environmental Sustainability	
Emissions Savings (auto)	\$0.03
Emissions Savings (truck)	\$0.01
Sub-Total Environmental Sustainability	\$0.04
Quality of Life	
Fiber Benefit	\$7.4
Sub-Total Quality of Life	\$7.4
O&M Costs	-\$10.3
Net O&M	-\$10.3
Total Benefits	\$25.9
BC Ratio	1.27
Net Benefits	\$5.5

Table 11 – Wayside Road Project Benefit-Cost Analysis (2025-2054 in 2017 \$M)

	Discounted at 7%
Costs	
Capital Costs	\$12.3
Total Costs	\$12.3
Benefits	
Safety	
Reduced Highway Fatalities and Crashes	\$16.7
Sub-Total Safety Benefits	\$16.7
Economic Competitiveness	
Delays During Construction	-\$1.3
Travel Time Savings	\$25.6
Truck Operating Savings	\$1.2
Vehicle Maintenance Savings	\$0.0
Sub-Total Economic Competitiveness	\$25.5
State of Good Repair	
Residual Value	\$0.6
Resilience Repair Cost Savings	\$0.0
Sub-Total State of Good Repair	\$0.6
Environmental Sustainability	
Emissions Savings (auto)	\$0.03
Emissions Savings (truck)	\$0.02
Sub-Total Environmental Sustainability	\$0.06
Quality of Life	
Fiber Benefit	\$0.0
Sub-Total Quality of Life	\$0.0
O&M Costs	-\$0.4
Net O&M	-\$0.4
Total Benefits	\$42.5
BC Ratio	3.46
Net Benefits	\$30.2

List of Supporting Information

AECOM, BCA.xlsx (Excel spreadsheet with BCA calculations by benefit type and summary)

AECOM Safety Analysis:

AECOM Safety Analysis Memorandum.pdf

SafetyBenefitFactors.xlsx

Ft Bragg Crashes Avoided.xlsx

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Peterson, Richard, 2017, "Paying for Speed: Measuring Willingness to Pay in U.S. Broadband Markets," University of Colorado, October 17, 2017

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U.S. DOT, 2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs, <https://www.transportation.gov/sites/dot.gov/files/docs/mission/office-policy/transportation-policy/14091/benefit-cost-analysis-guidance-2018.pdf>

U.S. DOT, BUILD 2019 Notice of Funding Opportunity, <https://www.transportation.gov/sites/dot.gov/files/docs/subdoc/391/fy-2019-build-nofo-fr.pdf>